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**JOINT HEARING ON THE POTENTIAL IMPACT
OF GLOBAL WARMING ON THE THIRD WORLD**

JOINT HEARING
BEFORE THE
**COMMITTEE ON AGRICULTURE,
NUTRITION, AND FORESTRY**
AND THE
SUBCOMMITTEE ON FOREIGN OPERATIONS,
EXPORT FINANCING, AND RELATED PROGRAMS
OF THE
COMMITTEE ON APPROPRIATIONS
UNITED STATES SENATE
ONE HUNDRED FIRST CONGRESS
FIRST SESSION
—
SPECIAL HEARING
—

Printed for the use of the Committee on Appropriations



U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1989

98-234 —

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

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JOINT HEARING ON THE POTENTIAL IMPACT OF GLOBAL WARMING ON THE THIRD WORLD

WEDNESDAY, MAY 10, 1989

U.S. SENATE, SUBCOMMITTEE ON FOREIGN OPERATIONS,
COMMITTEE ON APPROPRIATIONS AND COMMITTEE ON
AGRICULTURE, NUTRITION, AND FORESTRY,

Washington, DC.

The subcommittee and committee met at 10:05 a.m. in room SD-192, Dirksen Senate Office Building, Hon. Patrick J. Leahy (chairman) presiding.

Present: Senators Leahy, Kasten, Boschwitz, Gorton, Baucus, Conrad, Kerrey, Bond, and Nickles.

NONDEPARTMENTAL WITNESSES

OPENING REMARKS OF SENATOR LEAHY

Senator LEAHY. The joint meeting of the Senate Committee on Agriculture, Nutrition and Forestry and the Subcommittee on Foreign Operations of the Senate Committee on Appropriations will be in order. Senator Kasten and I will share duties on the Foreign Operations aspect and Senator Lugar and I and others on the Agriculture Committee will share duties on agricultural matters.

During the past few years I have tried when possible to have committees with possible overlapping jurisdiction hold joint hearings and in this case the Congress has before it the urgent task of developing policy responses to the potential impacts of global warming and major decisions have to be made.

In a December hearing the Agriculture Committee looked into the potential effects of global warming on U.S. agriculture and forestry. We know that U.S. agriculture and forestry are sensitive to variations in a stable climate. We learned about the sensitivity of agriculture and forestry to climate change. It is rather sobering.

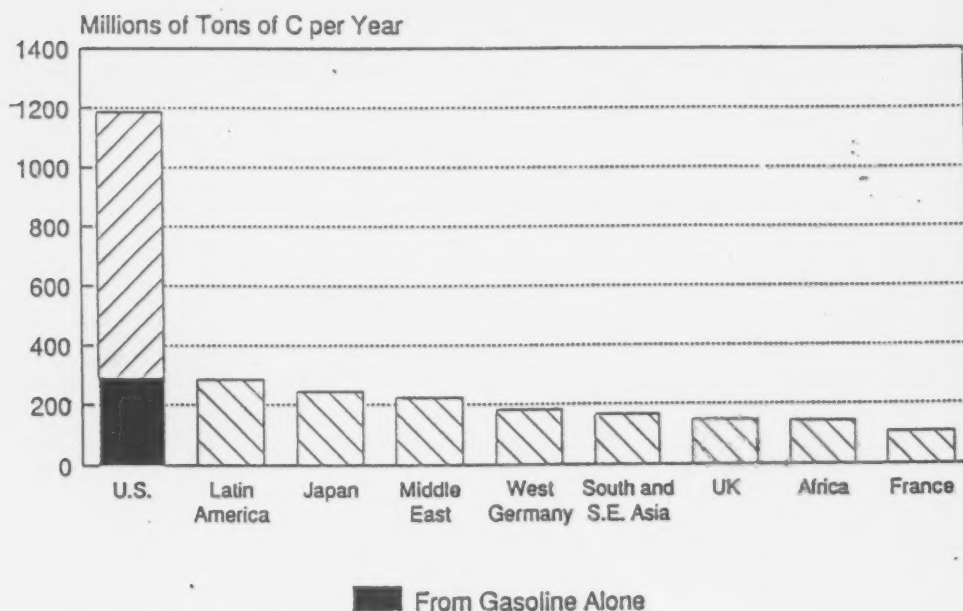
The potential for disruption of U.S. agriculture and forestry by a climate change is enormous and so is the potential for the disruption of world food security.

In our own country the changes that would occur in our economics, demography, and so many other areas is almost incalculable. So today's hearing, which is a joint hearing of the Agriculture Committee and the Foreign Operations Subcommittee, focuses on the implications of a potential climate change for the Third World. It will include a look at how the United States should respond to Third World needs in bilateral and multilateral aid programs.

There was a good running start during the presidential campaign on environmental issues and particularly on global warming and I was encouraged by some of the statements that the President made. I am also concerned that he may be backing off now, while all the other major Western nations have called for an international convention on global warming. The United States today has a leadership vacuum there.

I am concerned that the administration has not decided, or does not know whether or not global warming is a problem. I have two charts here that may enlighten them. The first one shows the relative contributions of the greenhouse gas carbon dioxide by the United States and other countries of the world.

U.S. CO₂ EMISSIONS COMPARED WITH THOSE OF SOME OTHER REGIONS (1985)



Source: World Resources Report 1988-1989

It is clear that the United States is by far the major contributor to the problem of CO₂ emissions. The emissions from just gasoline use alone in the United States is greater than all the CO₂ emissions in all of Latin America; it is greater than all the CO₂ emissions in the Middle East; it is almost twice the total CO₂ emissions in Africa.

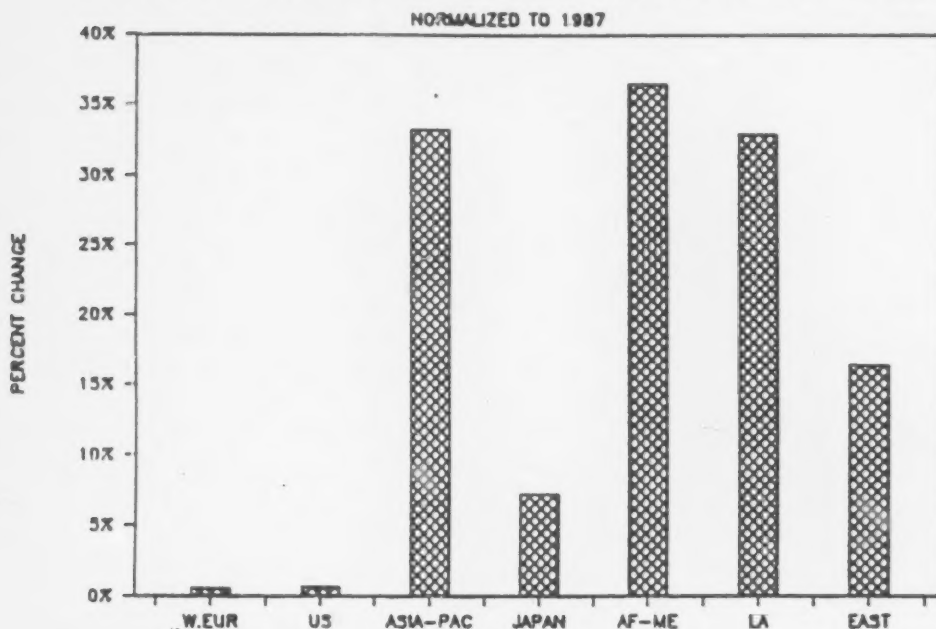
So the United States must provide leadership on the global warming issue. To do that we must get our own house in order for us to have the credibility that we need to do something world-wide about the greenhouse effect.

To reduce global warming we have to start here first and demonstrate that we are willing to take the tough steps necessary to do

it. We cannot preach to other countries while we do nothing to limit greenhouse gas emissions and continue with other destructive practices such as subsidizing the destruction of our own forests.

At the same time, we need to recognize trends world-wide in CO₂ emissions. Here, the second chart tells us that emissions in the rest of the world will rise rapidly. It shows new car registration trends to 1992. If you look at that, you see the United States and Western Europe on the left. You can barely see them.

NEW CAR REGISTRATION TRENDS 1987-1992



Then look at the increases in the Asia, Pacific, Africa, Middle East, and Latin America regions. They go almost off the chart. That demonstrates a global problem, which is why we want to look at new ways in which foreign assistance can be an effective tool for cooperation with other countries concerned about potential climate change.

Brazil, for example, has asked for environmental assistance. Is it not as much in our interest as theirs to respond positively in ways that promote energy efficiency in the conservation and sustainable use of tropical forests?

China and India are going to be major users of energy. Should we not help in providing the efficient technologies if they too want our help?

So I am now preparing legislation, for introduction in the near future, designed to address problems which may result from a warmer world. The witnesses we have today can make important contributions toward addressing the issues we are looking at as we put a bill together.

There are three major questions to which we hope to get answers today. First, what are some of the likely impacts of global warming

on Third World countries? Second, what implications are there for agriculture and for world food security. And third, what policy responses in the United States are necessary to develop cooperative programs with developing countries to address global warming issues?

Before we hear from the first panel of witnesses. I would like to yield to my friend and colleague the senior Senator from Wisconsin, Senator Kasten.

REMARKS OF SENATOR KASTEN

Senator KASTEN. Mr. Chairman, thank you and I want to congratulate you on this important hearing, which combines the interests of the Agriculture Committee and our Foreign Operations Subcommittee. This clearly is one of the most important, if not the most important, subjects that we face over the next several months and possibly the next several years.

It is an area in which we in the Senate Commerce Committee have been working. On Monday, in the Senate Commerce Committee, I learned that the Office of Management and Budget had changed the testimony of an administration scientist on the greenhouse effect. I was at that hearing and I think that what OMB did was inexcusable.

The Office of Management and Budget exists to review Federal expenditures, to ensure the testimony from agencies is consistent with the administration's positions, to develop costs of different proposals and even to develop cost-benefit comparisons and evaluations.

But OMB has no right to change the scientific findings of any Federal agency. We must not tolerate that kind of censorship. The only way to meet this problem is to be faithful to the truth, to use the best scientific information and to provide bipartisan leadership from the Hill and the White House.

At a time when we are calling on developing countries to act responsibly toward the environment, we cannot tolerate this kind of domestic action. We should be setting an example for the rest of the world so I am hopeful that we can deal with the problems that have now been created by that OMB testimony which has been so much in the news the last couple of days.

To accomplish these objectives today, I am calling on the President of the United States to give instructions to the Steering Committee on Global Climate Change—that is, working group 3 of the Intergovernmental Panel on Climate Change which the United States chairs, to lead the effort to develop an international convention on the greenhouse effect.

We can no longer question where the United States stands with regard to the international convention. It is going to go forward with or without our support, but it should go forward with our strong support, and I am calling on the President to give these instructions.

Second, I am calling on the White House to give our representatives to the United Nations Environmental Program [UNEP] instructions to make negotiations of a protocol on global warming UNEP's top priority.

In this subcommittee's mark of the fiscal year 1989 appropriations bill, we designated the negotiation of such a protocol to be our primary objective from UNEP and that appropriations bill was passed by the full committee, by the Senate, and then by the House and is part of the conference that became law.

The next meeting of the governing council of UNEP convenes next week. This meeting sets up the biennial budget of UNEP and the development of a convention on global warming must be the top priority for UNEP in the coming 2-year cycle.

So by accomplishing these two actions I think we can set the record straight on where this administration, this President and this Congress want to go in terms of leadership in this global warming question.

We are facing an international crisis that is a greater threat to human populations than we have ever faced before. The deterioration of global resources is threatening the most basic means of food production. It is appropriate, therefore, that we convene this joint meeting of the Foreign Operations Subcommittee and the Agriculture Committee to review this crisis and to determine what we can do about it.

PREPARED STATEMENT

Mr. Chairman, I ask unanimous consent that the remainder of my prepared statement appear in the record as if read and I look forward to hearing our witnesses today.

[The statement follows:]

PREPARED STATEMENT OF SENATOR ROBERT W. KASTEN, JR.

We are facing an international crisis that may be a more acute threat to human populations than we have ever faced before.

The deterioration of global environmental resources is threatening the most basic means of global food production. It is highly appropriate that we convene this joint meeting of the Foreign Operations Subcommittee to review this crisis and what we can do to face it.

The decisions we make in the next few years on revising our foreign assistance programs and agriculture research programs will determine how much most of the people of the world will have to eat in the next century.

According to the National Climate Program, the 1980's has been the warmest decade ever recorded. That increase in temperature is not limited to any country, but is experienced around the world.

The bulk of the scientific evidence indicates that global temperatures will continue to rise, perhaps even accelerate, in the next century.

A temperature increase of just a few degrees has a profound impact on agriculture. What once was a key grain producing area may be converted to an inhospitable environment for conventional forms of agriculture.

What makes this particularly catastrophic, is that agriculture in temperate zones may be threatened at the same time. For example, doubling a CO₂ loading is projected to create a 3 to 7 degree Celsius rise in summer temperatures in Wisconsin.

As last summer's soaring temperature and drought showed, a temperature increase, and corresponding changes in precipitation changes, could upset our nation's bread basket and unbuckle our dairy belt.

We could be face with decreasing agricultural production in temperate regions at the same time that tropical nations lose the ability to feed themselves.

In short, we are on the verge of turning the "Green Revolution" of the last 25 years into the "Brown Revolution" of the 21st Century.

To prevent this catastrophe we must today initiate revisions in our agriculture and foreign assistance programs to minimize and adapt to global change.

OPENING STATEMENT OF SENATOR LUGAR

Senator LEAHY. Thank you very much, Senator Kasten. I also have an opening statement from the ranking member of the Senate Agriculture Committee, Senator Lugar and without objection that statement will be made part of the record.

[The statement follows:]

PREPARED STATEMENT OF SENATOR RICHARD G. LUGAR

Mr. Chairman, I want to commend you for your foresight in holding this hearing. In the past few weeks a considerable amount of information has come to the fore with respect to the potential causes and suggested solutions to the problem of global warming. However, the actual interaction between a developed country and a developing country has not been addressed in detail. This is an important interaction to understand because it will be a critical element to any solution which will successfully address the problem of global warming.

Out of all the available information concerning global warming comes two clear messages. First, that we cannot wait until the issue is defined beyond any shadow of scientific doubt before preventative strategies are developed. And, second, that developed countries can and should play a major role in helping developing countries avoid the long-term environmental costs that appear to be associated with traditional economic development.

As a developed country, we must recognize the need to construct meaningful and effective national policies that fit within the master framework of a global strategy aimed at responding to a global problem. The fundamental objectives of such a strategy should be the development of programs that ensure sustainable energy and a sustainable ecology.

As a developed country, we must also recognize that we can play a pivotal role in the world-wide solution but that such a role will be ineffective if we attempt to generalize Western standards to the world as a whole.

In proceeding forward on the issue of global warming we must begin work now on responsive strategies that take into account adaptive capacities. At the same time we must continue our efforts to develop an international consensus on the science. The development of responsive strategies should, however, be sensitive to societal economic effects at both national and regional levels.

I look forward to hearing from our witnesses today.

REMARKS OF SENATOR BOSCHWITZ

Senator LEAHY. I yield to my good friend from Minnesota, Senator Boschwitz.

Senator BOSCHWITZ. I thank you, Mr. Chairman. I thank you for holding this hearing and the idea of holding it together with the Appropriations Committee certainly is a very constructive one. It is nice to see my friend from Wisconsin here as well.

I must say that there has been quite a flap in recent days about what has happened—the Senator from Wisconsin referred to it, with respect to altering testimony.

I must tell you, Mr. Chairman, I went through the same thing when I was a member of the U.N. delegation in the last session. I told the State Department I would join the U.N. delegation if I could go to the United Nations and speak about global warming.

They did not like that idea so much and they did not have a position and it was not absolutely explicitly unqualifiedly proven that global warming was taking place. I kept telling them we have to get on the advance side of the curve. If you get behind and you wait for the evidence to really pile up you might not be able to make the adjustments without having very substantial changes occur in our environment and our lifestyle here in the United States.

So we argued a great deal—not unlike what I have just seen happen. Finally they went over the speech that I wanted to give and made a whole bunch of changes. I kind of extemporized anyway, when I was giving the speech, so I said essentially what I wanted to say.

Then I went on to Geneva where the IPCC was meeting and spoke there again, because I felt it was so important that the position of the United States be made clear that we did have an interest. Certainly the interest in this issue is very, very heightened and that is a good thing, because we need to make some changes. Otherwise my State, your State and everybody else's will have to make some extraordinary changes.

You will recall, Mr. Chairman, that when Secretary Yeutter came before us for his confirmation hearing that we on the committee asked him about these subjects as well. The same occurred on the Foreign Relations Committee on which I serve, when Senator Baker came. Many of my questions to him were directed to environmental matters.

Certainly the administration is getting a sense that we mean business up here on the Hill and I remain convinced, I might say, that the President is and will be an environmental President. Sometimes you get overwhelmed by the bureaucracy. When you have several million people working for you I suppose it is hard to keep them all in line, even those who are pretty close. I must tell you that I believe that this President will emphasize these matters more than did President Reagan, who certainly did not bring great emphasis to environmental matters.

There is no question that we must do things and we must act. We must do it not only unilaterally but we must get our friends in other parts of the world to do the same. With the growth in population and the growth in living standards, the consumption of energy will rise and the levels of CO₂ certainly are not going to decrease.

Senator Gore and I have introduced a couple of bills. One is the Gore-Boschwitz bill that deals with domestic matters, CAFE standards and many other areas. Another is a bill that I authored, the Boschwitz-Gore bill. The bill directs that in foreign affairs and in the moneys that we spend internationally and the moneys that we give to international institutions, we should begin to condition those moneys on the basis of what the recipients are doing with respect to environmental values.

So the Senate and I think the Congress is on its way and I hope that we come to a speedy resolution of this problem, because it could change the way we live and it is important that we do it.

I thank you, Mr. Chairman and I have several other hearings to attend, as you may have also during the course of the morning, but I intend to read the testimony that is given in the event I am not here to hear it all.

Senator LEAHY. Thank you very much, Senator Boschwitz. I recall the statement that you made when you introduced your bills on global warming which you were kind enough to share with me. I appreciate it.

You and I have the advantage of being in elective office so we can say what we think without having to go all the way through the bureaucracy. I would urge the President, though, in his deter-

mination to be an environmental President to recall he too is elected and could move very quickly on some of these things, especially some of the global warming aspects.

Because I rather suspect his instincts are in the right place, he might be wise to follow his instincts sometimes and let the bean counters at OMB sort of review each others statement—that will keep them busy and keep them out of trouble.

Senator Conrad?

REMARKS OF SENATOR CONRAD

Senator CONRAD. Thank you, Mr. Chairman. Very briefly, I would hope that our Government would change its mind and decide to be involved in the international conference on this subject. Others have issued that call. I want to join them in that. I think it makes very little sense for us to be talking about the problem without participating with the other countries who can do something about it, so I want to add my voice to the others and say the United States ought to participate.

With that, Mr. Chairman, I will give back my time so that we can get to these witnesses.

Senator LEAHY. Thank you very much, Senator Conrad. Does anybody else have a statement. Senator Gorton?

REMARKS OF SENATOR GORTON

Senator GORTON. Thank you, Mr. Chairman. I will just ask that my opening statement be included in the record as if read and say that I want to associate myself with the thoughtful comments of Senator Kasten on this most important issue. I feel that he outlined the considerations in a first-rate fashion and I fully agree with them.

[The statement follows:]

PREPARED STATEMENT OF SENATOR SLADE GORTON

Mr. Chairman, I am pleased to be provided with this opportunity to join with the Appropriations' Subcommittee on Foreign Operations to hear testimony on the potential impacts of global warming on the Third World and possible policy responses by the United States.

Throughout my Senate career, I have advocated expansion of research efforts for our earth, oceans and atmosphere. In the past I have supported measures to establish a global foresight capability with respect to natural resources, the environment and population. I plan to continue to be actively involved in these efforts, and have already joined Senator Wirth in cosponsorship of his Omnibus Global Warming Initiative (S. 324).

As you know, Mr. Chairman, there is a growing concern and increasing evidence that mankind is dangerously altering the Earth's atmosphere through the introduction of huge quantities of "greenhouse" gases. The continued alteration of our atmosphere may fundamentally change the conditions governing life on Earth by altering the basic climatic conditions under which we live. Perhaps nowhere may the impact be more severe than in the Third World.

In my view, the U.S. must take a strong leadership role by aggressively bringing the greenhouse effect issue to the attention of the global community, leading the world community in emissions reductions and developing safe, economic and reliable technologies. The greenhouse effect problem is not just a U.S. problem. It is a global problem and must be addressed by the entire global community.

Appropriate action could delay the deepening of greenhouse effect by half a century or more. Such a delay could be crucial, and could spell the difference between disastrously rapid climate change and a manageable transition.

That concludes my opening statement Mr. Chairman. Again, I thank you for scheduling this hearing and I look forward to hearing the testimony to be presented to us today.

Senator LEAHY. Senator Kerrey?

Senator KERREY. I have no opening remarks.

Senator LEAHY. Senator Bond?

Senator BOND. Thank you Mr. Chairman. Oh, wait a minute.

Senator BOSCHWITZ. I asked him, what about my statement? He did not listen.

Senator KERREY. He was talking about thoughtful statements.

Senator LEAHY. Sooner or later, Rudi, somebody is going to agree with you. Do not feel bad. Heck, I have even agreed with you on occasion, you know that.

Senator Bond?

REMARKS OF SENATOR BOND

Senator BOND. Mr. Chairman, I am delighted that the kinder and gentler atmosphere has not pervaded into the Agriculture Committee but I do want to——

Senator LEAHY. It does from the chairman.

Senator BOND. Excuse me. I should note that. I do want to commend you, Senator Lugar and our colleagues on the Appropriations Committee for holding this hearing. I have a statement that reflects some of the views that I have and notes some of the interesting elements in the testimony we have today.

I too would urge the administration to get moving and to get serious about the international cooperation needed to deal with global warming. We have heard the President say that he is committed to reviewing and acting on the problem and I think the time to do it is now—sooner rather than later. It is not an easy problem to solve. It is one that is going to require a great deal of international cooperation and the sooner we get on to it the better. I too hope that we see movement on it quickly and with that I would ask that the remainder of my statement be included in the record.

[The statement follows:]

PREPARED STATEMENT OF SENATOR CHRISTOPHER S. BOND

Mr. Chairman, I am pleased that under the leadership of both yourself and Senator Lugar, the Agriculture Committee has become involved in the issues surrounding global climate change. While some scientists have warned of significant changes for several years, it wasn't until recently that their concerns were deemed valid. Today, global climate change is a reality. The question is no longer what if, but when and to what extent.

The seriousness of continued drought conditions in this country underscore the disruptions associated with climatic changes. Absent the large quantities of agricultural commodities in storage last year, the impacts of the drought would have been far more dramatic. Continued drought conditions could be disastrous for not only producers, but consumers throughout the world.

The more I learn about global climate change the more concerned I get. Today's witnesses state that we will experience some climate changes even if we take immediate, drastic efforts to reduce the emission of greenhouse gases. In other words, even if these two committees had the authority to make the changes necessary to reduce emissions significantly, we will still experience increased temperatures, and different precipitation patterns. While it is highly unlikely that major reforms can be initiated in a short period of time, I would hope we can address this situation before our planet resembles Mars.

Although the implications of global climate change are important in the U.S., we must also be concerned about the ramifications in other countries—especially less developed countries. While the U.S. produces many different crops, other nations may depend upon less than a handful. In his statement, Mr. Teramurer provides interesting insight on the impacts of climate change on rice production in Southeast Asia. An important staple, rice production could be seriously affected by even slight warming trends. Potential food shortages raise very serious social, economic and security concerns.

Aside from the basic issue of self-sufficiency many countries could be faced with severe trade problems. In recent years, countries such as Brazil have come to rely upon agricultural export earnings to generate foreign currency to meet international debt obligations. Climate changes which result in decreased agricultural production exacerbate an already bad situation with regard to third-world debt.

Reading over the testimony, I noticed a consensus in the call for additional research throughout the entire spectrum of this issue—from the exact contribution of the various greenhouse gases, the effects on various locations, the potential for breeding tolerance into new and existing crops and the implications for Third-world countries.

Mr. Chairman, I thank you for your efforts in this area and look forward to working with my colleagues to address this crucial issue.

PREPARED STATEMENT OF SENATOR D'AMATO

Senator LEAHY. Thank you very much. Senator Bond. I will leave the record open for other statements.

[The statement follows:]

PREPARED STATEMENT OF SENATOR ALFONSE D'AMATO

Thank you, Mr. Chairman. I want to welcome our panel of experts. I appreciate your appearing this morning to testify.

My questions to you gentlemen are two: (1) How do we foster continued third world growth when we must urge less developed countries to halt deforestation and limit the burning of wood and fossil fuels?, and (2) How do we begin counteracting the deleterious effects of the industrial revolution on the environment?

I understand why some in the third world consider the greenhouse effect to be a ploy created by the rich to keep poorer nations undeveloped. It must strike many in the third world as hypocritical that the west has achieved a new consciousness about industrialization and its negative impact on the environment after it has conveniently completed its own period of development. If we are going to begin to address this issue in a serious way, we have to be able to provide less developed countries with a means of developing that is: (1) no more expensive than the path they are currently following, (2) environmentally sound, and (3) effective.

I have read report after report ominously intoning the dangers of the greenhouse effect, yet not once have I come across an article in which anyone offered one bit of a solution as far as counteracting the build-up of carbon dioxide in the upper atmosphere. How do we eliminate this build-up? I would be very interested to hear any suggestions any of you gentlemen may have as to solutions.

Thank you, Mr. Chairman.

INTRODUCTION OF PANEL ONE

Senator LEAHY. Let us have the first panel of witnesses come up to the table at this time. Dr. William Riebsame, who is the Director of the Natural Hazards Program, University of Colorado, Dr. Houghton, Woods Hole Research Center and Dr. Alan Teramura, the Acting Chairman of the Department of Botany, at the University of Maryland.

Gentlemen, I am delighted to have you here on a rainy day, but you can think of this as a two-fer—you get two major committees at once. You all have been concerned with this issue for a long, long time and I hope you can take some heart from the heightened concern on the part of the Congress and Members of both parties, I might hasten to add. Certainly in conversations with other Sena-

tors, again of both parties, I find more and more concern about it. Maybe they hear the same way as I do from my three children. They make sure I am concerned.

STATEMENT OF DR. WILLIAM RIEBSAME, DIRECTOR, NATURAL HAZARDS PROGRAM, UNIVERSITY OF COLORADO

Senator LEAHY. So we will go in the order—I think, Dr. Riebsame you are first? Dr. Riebsame, go ahead.

Dr. RIEBSAME. That is fine.

Mr. Chairman, I have written comments that I ask to be entered in the record.

Senator LEAHY. They will be.

Dr. RIEBSAME. Then I will speak generally to those comments. By way of introduction I should say I am a geographer and I study the interaction of people and their environment broadly speaking, so I am not going to talk in the next couple of minutes about specific details of whether or not crops in specific areas of the world can be adapted to climate change. I want to talk about the general issues of how well societies at different levels of development can deal with rapid climate change.

One of the themes that is going to run through my comments is the need not only to be paying attention to limiting greenhouse gas emissions but also to deal with the adaptability and the resiliency of natural resource management systems around the world. I will particularly address the Third World situation.

Here is my assessment of the global warming greenhouse effect issue. First, since about the mid-1970's atmospheric scientists have given us credible evidence that there is a reasonable threat of global warming, and other types of climate change, in the next few decades.

My reading of the literature is that since then, there has been no credible challenge in that every piece of research, and most of the new evidence, has continued to support this concern for about a decade now. There really is no credible challenge although scientists, of course, as is the way of science, are trying to challenge it and that is as it should be.

Thus, the concern I think is real. The evidence suggests that even small, average changes in climate can cause noticeable changes in the frequency and the magnitude of droughts, floods, freezes, and heat waves and that is the stuff that farmers deal with. Those are the events that people experience in their daily lives and that occasionally threaten natural resource management systems.

My second point is this: while we may be uncertain, though, about the distribution and the exact rate of changes in climate over the next few decades and you all know about the uncertainties, we are not at all uncertain about the sensitivities in natural resource management systems, some of which are very sensitive even to small climate fluctuations, much less rapid climate change, especially in the developing world.

About a year ago I reviewed the climate impacts literature for the U.N. Environment Program and these were my basic conclusions: One, the methods that we have for assessing these impacts are sound and they give us reliable estimates—as reliable, of

course, as the climate data—and two, when you look over the climate impacts literature what you find is that small changes in climate can have large impacts on critical elements like crop yield and water resource management. Not all of the impacts are negative, of course, but the negative ones are quite serious.

Third, I would like to raise the question of how well or fast different societies can adapt to climate change. I think adaption has been neglected in our attention on immediate impacts and on the need to limit greenhouse gas emissions. Both are going to be necessary.

The EPA report—the so-called stabilization report—tells us how difficult it is to limit greenhouse gas emissions immediately and even if we did take drastic action now, we have what atmospheric scientists call a warming commitment built up in the system.

I think now, despite the remaining uncertainties, it is time to assess the sensitivities and the adaptabilities of societies around the world. I am especially concerned about the Third World. A combination of factors there makes societies very vulnerable to climate impact. Economic well-being is much more closely tied to primary natural resource productivity and many Third World societies have lost resilience to climate shocks—lost the ability to adapt.

Over the past few decades we have worked hard to encourage rapid economic growth in the Third World and to an extent I think we have neglected the need to increase the fundamental resiliency of Third World societies through strengthening institutions of family, the farmers themselves, local government, and National Government.

Let me just give you a quick example. Since the 1950's we have been involved in something called integrated river basin development around the world. In fact, we kind of invented it with the Tennessee Valley Authority and we have helped basins like the Senegal in West Africa, the Indus, the Mekong—Bureau of Reclamation engineers were in the Mekong before the war heated up. We have helped them develop the facilities and the management schemes for water resources and related issues. Now, some of those efforts have been successful; some have been less than successful. Some are being reviewed by AID and other agencies, but not a single one has been carefully reviewed for its sensitivity to potential changes in climate.

We are entering a critical time in which we are reevaluating our approach to Third World development and while we are doing this I think we desperately need a comprehensive assessment of how adaptable Third World natural resources systems are.

I think there are many vulnerable populations out there. Experience in Third World development suggests that often the process at first raises the sensitivity to climate impacts, rather than lessens it.

You might say that there are groups that are caught in the transition between relatively flexible traditional systems and modern systems that have institutions like insurance and aid and extension, and in this transition they exhibit what can be called a gap in their adaptation repertoire—the coping mechanisms that they had when the droughts and floods came in the past.

We need to bridge that gap, maybe even to create sort of resiliency report cards for developing societies and identify what sorts of climate impacts they are sensitive to.

I will end with a recommendation—a simple recommendation that as we proceed to help the farmers in Tanzania, or the smallholders in northeast Brazil, or the tenant farmers in the arid zone of India—as we continue to help them develop, we should ask these three simple questions of every effort, or every project: first, how sensitive is this project to possible climate changes? Whether the climate gets warmer, or drier, or wetter, or colder does not matter. How sensitive is it to those changes?

Second, does this project or this development add to the greenhouse gas problem? Third, what options are we offering resource managers in the Third World in case rapid climate change were to begin?

PREPARED STATEMENT

I think those three questions should be asked of every major resource development effort undertaken, especially by unilateral or bilateral donors, and I think that we need to transfer the methods for asking and answering those questions to resource managers in the field. Right now, mostly researchers like myself are conducting climate change impact studies. I think that it needs to be addressed on a regular basis in the resource planning process both internationally and domestically.

Thank you.

Senator LEAHY. Thank you very much.

[The statement follows:]

STATEMENT OF WILLIAM E. RIEBSAME

Abstract

Increasing greenhouse gases in the earth's atmosphere will cause noticeable climate changes affecting the frequency of droughts, floods, freezes, and heat waves over the next several decades. While atmospheric scientists disagree over the exact nature of these changes, there is no doubt that many of our systems for producing food, water and energy are vulnerable even to current climate fluctuations, which could be considered "normal". Thus, we should begin now to evaluate and lessen this sensitivity, especially in developing countries. As the threat of climate change emerges, many Third World populations are trapped between traditional and modern resource management systems, and have lost the social resiliency needed to adapt to environmental change. We need to recognize this vulnerability, and begin to plan development in a more flexible way. Despite uncertainty over details, the threat of global climate change is sufficiently credible that three questions should be asked of every resource development project (both international and domestic): (1) how sensitive is the plan if the climate were to become warmer, drier, wetter or colder; (2) does this development add to the greenhouse gas problem; and (3) what options would resource managers and users have in the face of rapid climate change?

Introduction

By way of introduction I should say that I am a geographer who studies the interactions between people and their environments, and since 1978 I have focussed my work on climate impacts on natural resources like water and agriculture. As such, I will not address such narrow topics as impacts and adaptability of particular crops or water systems. Rather, I will address the more fundamental question of how well societies at different stages of development are likely to handle rapid climate change. I will focus chiefly on Third World countries, and on the role of development projects in making these countries more or less sensitive to climate change.

I will address two questions:

- 1) How adaptable are Third World societies, and their natural resource systems, to rapid climate change? Can they handle it?
- 2) How can we measure and improve social resiliency in the face of potential rapid climate change?

1) How Adaptable?

The adaptation issue has been neglected in our attention on strategies to prevent greenhouse gas accumulation and to limit climate change. The fact is that both limitation and adaptation tactics must be considered. Recent studies on limiting global warming (such as the EPA "stabilization report") conclude that significant climate change is likely even if we take immediate, drastic actions to reduce greenhouse gas emissions. We are faced, in greenhouse parlance, with a significant "warming commitment" that will cause changes in sea level, and the frequency and intensity of droughts, floods, freezes and heat waves. I believe that despite the remaining uncertainties about the rate and distribution of climate change, we must begin now to assess the sensitivity and adaptability of natural resource management systems.

The bad news is that Third World countries, whose economies are dominated by agriculture and who have experienced uneven and occasionally abortive development, are the most at risk from

climate change. Over the past few decades of attempts to spur rapid economic growth and avert crises in the Third World we have neglected the need to increase societal resiliency to shocks like climate change. Despite the fact that we have been aware of a credible threat of climate change for over a decade now, very few efforts are underway to assess how well the resource systems that act as anchors for regional development--like the integrated river basin development programs--can manage in a rapidly changing environment.

We are entering an especially critical time in natural resources development around the world. Growing criticism of development strategies has led to some re-evaluation, and some aid institutions are paying more attention to environmental and social impacts, but not to the potential for climate change per se. And, there may be some good signs showing up on the development horizon. The World Bank has just reported that Sahelian Africa is beginning to recover after a decade of aborted development. They claim that new development strategies have begun to yield, since 1985, a slow improvement in per capita food production, which had been declining for a decade. Accepting this trend (which I suspect may be as much due to improved rains as of appropriate development), I cannot help but worry whether we will disregard the lessons of the 1960s and 1970s and neglect the need to assure that future development is less sensitive to climate fluctuation, whether natural or anthropogenic. By neglecting the issue, just as we are turning the corner on development, rapid climate change could derail future success.

We need a comprehensive evaluation of the resiliency of natural resource systems around the world so that we can identify the factors that make people more or less resilient in the face of events like climate change. Most of the climate impact assessments conducted to date suggest quite serious impacts from even relatively small climate changes, including shifts in agricultural zones, changes in the performance of water supply systems, and loss of fertile lands in low-lying coastal deltas, such as in Egypt and Bangladesh (see, for example, Kates et al. 1985; Parry et al. 1988; Riebsame 1988). Significant impacts on food production have also been projected for developed countries as well: reduced rice yields in Japan, and changes in U.S. food exports (Environmental Protection Agency 1988). There may also be positive changes, but the potential negative ones are sufficiently serious to raise real concern over future social and political stability.

While we can project direct impacts-with reasonable certainty, the ability of any society to adapt to rapid climate change--positive or negative-is less well known. Climate impact researchers have been driven by the immediacy of the issue to focus on direct climate impacts on, say, crop yields or runoff, in narrow, quick-and-dirty impact studies. But we have not taken a more careful look at potential adaptability of resource systems. On that question we are forced to rely chiefly on intuition or conventional wisdom. For example, some simply argue that humans ingenuity and technology can cope with climate change as it has with other problems. But, each optimistic statement can be countered with a more pessimistic one. Some analysts argue that international food trade can absorb significant climate change, if the market system is allowed to function. But, other studies, like the EPA's "Effects Report," suggest that export supplies will also be affected. Some point optimistically to past adaptations to climate impacts, but others simply remind us that resource systems are now stressed by populations larger than ever before.

2. How can we measure and improve social resiliency in the face of rapid climate change?

We need a better assessment of social resiliency, especially in the developing world. Otherwise, we really cannot say who will be hurt in the process of adapting, and which areas and populations might be unable to cope with climate change. This is a challenge to which the social sciences are just beginning to respond. The goal now, I believe, should be to conduct an integrated assessment of social adaptability under rapid climate change. What we learn from this analysis can improve our management of resources in the face of social or physical shocks, some of which are inevitable, like fluctuations in the current climate and further rapid population growth in some areas.

The analysis must be integrated and comprehensive. When policy-makers ask the question: "Can society deal with climate change?", they must be wary of one-dimensional answers. The resiliency of an agricultural system is not based just on how adaptable the cultivars are, but on the social infrastructure that keeps farmers farming and food trading. Social resiliency requires functioning cultural, institutional, economic, and technological systems, as illustrated in Figure 1. If any of these is weak in the face of climate change or other shocks, then the overall social system is weakened.

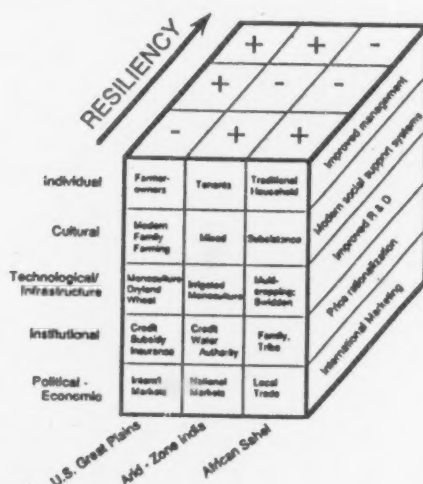


Figure 1. A schematic of the social elements that together determine vulnerability and adaptability in the face of rapid climate change.

We should prepare "resiliency report cards" for critical areas where future climate change might be especially problematic. This is needed not just in Africa, but in other places facing development problems that could be worsened by climate change, like northeastern Brazil and parts of Nepal.

We especially must pay attention to societies in transition from traditional resource systems to more modern systems (Figure 2). Studies have shown that most traditional systems are adaptable and resilient (for instance, a 10-year study of Kenya's Turkana people, conducted by Colorado State University, showing how well this group has dealt with recent droughts). Modern systems are also quite flexible. But, groups in transition often

suffer gaps in their "adaptation repertoire." In many societies, traditional coping mechanisms have been stripped away in efforts to improve agricultural productivity and trade position (see, for example, Watts 1983 on northern Nigeria). But new coping mechanisms, like credit and insurance institutions, are not yet in place or sufficiently strong to handle climate impacts.

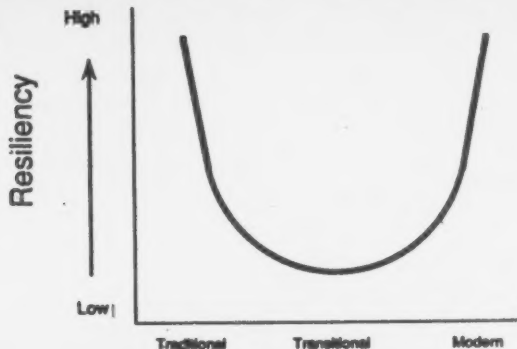


Figure 2. Relationship of development and social resiliency to shocks like climate fluctuations.

Scores of groups and countries are in this bind. The threat of global climate change points to the need for a new assessment of Third World development and its resiliency.

Recommendations: What We Can Do Now

Rather than simply "wait and see" if climate change disrupts development in the Third World (and in the industrialized countries for that matter), we should start now to evaluate and enhance social resiliency. The assessment methods exist, and emerging institutional structures like the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Environment Program's World Climate Impacts Program are slowly developing the strength and credibility to conduct the necessary sensitivity and adaptation studies.

We need to further strengthen these institutions, and to embark on a more holistic analysis of social adaptability. We must avoid one-dimensional analyses and answers, and begin to recognize the interaction of social vulnerability, climate fluctuation, and the root human causes of climate change.

I suggest that we simply ask these three questions of every major effort to improve resources development:

- 1) How sensitive is this project if the climate were to get warmer, drier, colder, or wetter?
- 2) Does this development add to the greenhouse gas problem?
- 3) What options would the resource managers and users have if the region entered a period of rapid climate change?

We have the methods to do this, and, in my opinion, the process would not add significantly to the costs of resource planning. But, the assessment methods are now being used only by researchers. They need to be transferred to resource planners and managers, and, given the threat of global warming, must be applied on a regular basis in the resource planning process, both international and domestic.

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STATEMENT OF DR. RICHARD HOUGHTON, Ph.D., SENIOR SCIENTIST,
WOODS HOLE RESEARCH CENTER

Senator LEAHY. I would like to go through the whole panel and then open it up for questions. Dr. Richard Houghton, who is going to speak on the issue of deforestation and reforestation, the carbon dioxide content of the atmosphere—actually, all three witnesses, obviously have interrelated testimony and issues—and then we can go to the questions.

Dr. HOUGHTON. Thank you, Mr. Chairman.

I ask that my written comments be included in the record, and I would make some summary comments.

Senator LEAHY. They will be included, and I would note for those in the press and others who are following this, Dr. Houghton's statement has both charts and number of figures and graphs, and goes into scientific detail as all the statements do.

Senator BOSCHWITZ. You ought to include Dr. Riebsame's entire statement as well.

Senator LEAHY. Yes; the whole statement will be in. And I should also note to the witnesses, too, when we have questions afterward, you will get copies of your testimony. And if you are like me, usually about half way home you think of one more point you might want to have made on an answer, and we will give you the chance to add that to it. Of course, you can correct anything you want because in this hearing, the testimony will serve as part of the bedrock in some of the legislation we will be considering.

Go ahead, sir.

Dr. HOUGHTON. Thank you.

Deforestation releases carbon dioxide to the atmosphere because of the burning and decay of plant material and soils associated with deforestation. The converse is also true: the regrowth of forests withdraws carbon dioxide from the atmosphere and stores it again on land.

The two processes, deforestation and reforestation, thus affect the carbon dioxide concentration in the atmosphere.

In 1980 deforestation in the tropics was about 11 million hectares per year. That is equivalent to the size of the State of Pennsylvania or Louisiana each year. Reforestation was about one-tenth of that; the ratio of deforestation to reforestation was about 10 to 1.

There were two independent studies carried out, two comprehensive studies for deforestation, both in about 1980. And although

their estimates agree for the entire tropics, they have large differences between them for some of the regions. So we really do not know the accuracy of this estimate of 11 million hectares per year.

Neither of the studies was able to use much of the data from satellites useful in evaluating deforestation.

The release of carbon dioxide to the atmosphere as a result of this deforestation is estimated to have been somewhere between one-half and 2½-billion metric tons of carbon. For comparison, the release of carbon from emissions of fossil fuels, worldwide, is about 5½-billion metric tons.

So the contribution from deforestation is on the order of 25 percent of the total emissions of carbon dioxide to the atmosphere.

Now, the range this one-half to 2½-billion metric tons is broad. And part of that range results from uncertainty in those rates of deforestation, part of it from uncertainty as to how much carbon is in the forests that are being cleared.

I am going to say nothing about deforestation and reforestation outside the tropics. We think that in recent years the net release of carbon has been close to zero. That is, that deforestation and reforestation are small outside the tropics compared to in the tropics, and that small releases of carbon dioxide from deforestation are approximately in balance with small accumulations from reforestation in those systems.

Since 1980 there has been no systematic appraisal of deforestation for the tropics. There have been a few places analyzed with satellite. And in those places the rates of deforestation have increased dramatically. The most notable of those is the Amazonian Basin, which probably most of you are familiar with. There the rates of deforestation appear to have increased by a factor of 3 in the 7 years between 1980-87. There is always the possibility that both of the estimates were somewhat in error.

But it looks as though in the Amazon Basin of Brazil, in particular, rates of deforestation have increased considerably since 1980, when the last comprehensive analysis for the entire tropics was carried out.

Just a word about what may be in store in the future. I think of the future as holding three potential strategies; the first strategy is business as usual. That is, if current trends in rates of deforestation continue, we will lose the tropical forests in both Latin America and Asia before the end of the next century. That is, in the next 50 to 100 years.

The good news is that once these forests are gone, there will be no more releases of carbon dioxide from deforestation there. But in the interval, we may have released on the order of 100 to 350 billion metric tons of carbon into the atmosphere. That is equivalent to how much carbon has been released from fossil fuels since the start of the industrial revolution, equivalent to or twice that industrial release.

On the other hand, one need not continue the trends that are proceeding now in the tropics. If the trends were to be reversed, that is, if deforestation were to be halted and reforestation started in a massive way, carbon could be withdrawn from the atmosphere and stored again on land on the order of 100 billion metric tons to 150.

The halting of deforestation and starting of massive reforestation is the second strategy. The problem with this second strategy is that although it works very well in the short term, as soon as forests have grown to maturity they no longer accumulate carbon. The carbon that has been accumulated remains stored, but there is no further accumulation, no further reduction in atmosphere carbon.

That brings me to the third strategy, which is to replace fossil fuel energy with wood-derived energy. To the extent this substitution were to be made, the carbon released from burning wood, would be balanced by carbon stored in regrowing forests. So the net release of carbon to the atmosphere would be zero.

I will summarize these three strategies, supposing they were in effect in 1980. The total emissions of carbon to the atmosphere in 1980, from both fossil fuel and deforestation, were on the order of 7 billion metric tons—first strategy. If deforestation were stopped and reforestation begun—second strategy—the total annual emission might be on the order of 4 billion metric tons. In other words, the emissions from fossil fuels continue, but some carbon is withdrawn from the atmosphere and accumulated in reforested lands.

The third strategy leads to a net emission of zero. That is, there are no emissions from fossil fuels. Instead the emissions are from wood-derived fuel sources, and these releases are balanced by storages on land in regrowing forests. The area required for the production of the required wood is on the order of 500 to 1,000 million hectares. The area is huge. It is the size one-half of the United States or all of it. But from another perspective, it is one-third of the world's area in croplands, it is one-third the area already managed. It is a fifth of the tropical forests now.

PREPARED STATEMENT

And, the replacement of fossil fuels with renewable, sustainable fuels seems to me ultimately to be the type of sustainable solution we are seeking.

Thank you very much.

Senator LEAHY. Thank you very much, sir.

[The statement follows:]

STATEMENT OF RICHARD A. HOUGHTON

My name is Richard Houghton. I am a senior scientist at the Woods Hole Research Center in Woods Hole, Massachusetts. I have been investigating the exchanges of carbon dioxide (CO_2) between the land's surface and the atmosphere for about 12 years.

Deforestation causes a release of CO_2 to the atmosphere because the carbon contained in plants and soil is oxidized to CO_2 during the burning and decay associated with deforestation. Forests contain between 20 and 100 times more carbon per unit area than croplands or pasture, so the transformation of forests to cleared lands results in a loss of carbon from land and an increase in carbon (as CO_2) in air. The contrary is also true: reforestation removes carbon from the atmosphere and stores it again on land.

The amount of carbon released to the atmosphere as a result of deforestation and reforestation is estimated to have been between 0.4 and 2.5 billion metric tons (BMT) of carbon in 1980 (Houghton et al. 1985, Detwiler and Hall 1988). This range is approximately 10 to 50% of the carbon emitted from combustion of fossil fuels (5.25 BMT) in 1980. Almost all of the carbon released to the atmosphere from deforestation in 1980 was from the tropics (Fig. 1). Outside the tropics the rates of deforestation are currently low and approximately balanced with rates of reforestation (Houghton et al. 1987).

The net flux of carbon from deforestation and reforestation cannot be measured directly. Instead, the flux is calculated from three kinds of information: (1) rates of deforestation and reforestation, (2) the amount of carbon contained in forests, and (3) changes in vegetation and soils following the transformation of forest to agriculture or of agriculture to forest.

Uncertainties in these three kinds of information are responsible for the range of estimates of carbon emissions (0.4 to 2.5 BMT in 1980). Uncertainties in the third factor, changes in vegetation and soil following deforestation and reforestation, are less important than uncertainties in the first two factors and will not be considered further.

THE CARBON CONTENT OF TROPICAL FORESTS

Estimates of the amount of carbon held in the vegetation of tropical forests differ by a factor of two (Brown and Lugo 1984). This uncertainty is probably responsible for about half of the range in the estimates of net flux. The higher estimates are based on direct measurement of the mass of plant material at a small number of sites. The lower estimates are based on measurements of commercial wood volumes at a large number of sites. When the commercial volumes are converted to total mass of plant material, the resulting mass is about half the value obtained from direct measurements. The discrepancy has not yet been resolved, although work in progress shows that the estimates based on commercial volumes have probably been 25 to 50% low (Brown et al., in press). Adjustments for these new values will raise the lower estimate of the flux of carbon by a few tenths of a BMT. Thus, the lower estimate of the net release of carbon is about 1 BMT in 1980. Another likely explanation for the difference is that many tropical forests have been degraded as a result of logging, fuelwood harvest, and other activities. In the final analysis, it is the carbon content of the forests actually being cleared that is important, and not the average content of all forests. The geographic detail necessary to assign specific carbon stocks to specific locations is being compiled.

RATES OF DEFORESTATION

1980

In the years around 1980, the total rate of deforestation of both closed and open forests in the tropics was about 11 million ha per year (1 ha = 2.47 acres), an area the size of Pennsylvania or Louisiana. The two most current studies of tropical deforestation show similar estimates for the tropics as a whole, but also show large differences (as much as 80% in tropical Asia) in specific regions (see Table 1). The two comprehensive studies of

deforestation for all the tropics were both carried out in the late 1970's. One study was supported by the National Research Council (Myers 1980), and the other was conducted jointly by the Food and Agriculture Organization of the United Nations and the United Nations Environmental Program (FAO/UNEP 1981, Lanly 1982).

Table 1. A comparison of estimates of tropical deforestation in 1980 (millions of hectares) (from Houghton et al. 1985.)

	Closed Forests		All Forests
	FAO/UNEP	Myers	FAO/UNEP
Tropical America	4.1	2.7	5.4
Tropical Africa	1.3	1.6	3.7
Tropical Asia	1.8	3.2	2.0
All tropics	7.2	7.5	11.1

The studies by FAO/UNEP and Myers disagree in their estimates of what has been happening to areas of shifting cultivation. Shifting cultivation is a common practice of land use in the tropics in which short periods of cultivation and cropping alternate with long periods of fallow or abandonment. During these periods of fallow, forests regrow at least partially. According to Myers, about 10 million ha of fallow forests were being converted each year to permanently cleared land. The FAO/UNEP study, in contrast, estimated that the area of fallow was increasing annually at a rate of 3 million ha. The uncertainty that this discrepancy introduces into the estimated flux of carbon is as much as 0.8 BMT per year (Houghton et al. 1985).

Since 1980

Since 1980 there have been no estimates of deforestation for the entire tropics and only limited estimates of deforestation for individual countries or states within countries. Most of the work has centered on states within the Brazilian Amazon (Woodwell et al. 1986, 1987; Malingreau and Tucker 1988). The Production Yearbooks of the FAO report annually the area of forests and woodlands for each country of the world, but these statistics are obtained from questionnaires sent to representatives of each national government, and many countries do not have up-to-date estimates of their areas of forest.

Because there are only limited data available since 1980, the rates of deforestation have generally been assumed to have remained constant since that date. For the part of the world for which we have data, however, the picture seems to have changed dramatically. Setzer and Pereira (1988) recently estimated the rate of deforestation in the Brazilian Amazon Basin. Their estimate was based on AVHRR data from the NOAA weather satellites. By counting the number of fires recorded by the satellite, Setzer and Pereira estimated that 8 million ha were deforested in 1987. In contrast to this 1987 value of 8 million ha for the Brazilian Amazon, FAO/UNEP (1981) estimated the following rates for 1980 and 1985:

Table 2. Annual rates of deforestation according to the FAO/UNEP (1981) survey of tropical forests.

	1980	1985		
	closed	closed	open	total
all Brazil	1.5	1.5	1.0	2.5
all Latin America	4.1	4.3	1.3	5.6
all tropics	7.3	7.5	3.8	11.3
1987				
Brazilian Amazon (Setzer and Pereira)		3.2	4.8	8.0

If the estimates of both the FAO/UNEP and Setzer and Pereira are correct, the rate of deforestation in Brazil has increased by more than 200% in closed forests and by more than 400% in open forests. The total rate has increased by more than 300% in 7 years (or 2 years). Setzer and Pereira report that the rates of deforestation in those states where most deforestation is occurring have been increasing at a rate of 30% yr^{-1} .

If the rest of the tropics has had similar changes since 1980, the current net flux would be three times what it was in 1980. It is unlikely that deforestation in the rest of the tropics is keeping pace with Brazil, where both national goals and commercial interests have been promoting the expansion of cattle lands in the largest area of tropical forest remaining on earth. The state of knowledge of current changes in forest area are so poor, however, that such changes cannot be ruled out. Although both tropics-wide studies referred to above (FAO/UNEP and Myers) made limited use of satellite data, most of their estimates were based either on traditional forestry surveys or on assumptions concerning population growth and per capita use of land. There is thus the possibility that, although the two estimates agree, they are both wrong.

The lack of knowledge concerning deforestation since 1980, perhaps including 1980, is remarkable given the importance of deforestation to climatic change and the demonstrated ability of existing satellite data to measure changes in forest area (Woodwell et al. 1983, Woodwell et al. 1987, Malingreau and Tucker 1988). The rapid rate of change in Brazil suggests that the routine monitoring of the world's forests with satellite is an important component to estimation of the net flux of carbon between land and the atmosphere. The U.S. could carry out such a monitoring today with a combination of AVHRR imagery from the U.S. weather satellite and MSS or TM imagery from Landsat. The total cost would be less than \$5 million.

The future

Projections of the 1980 trends of tropical deforestation to the year 2100 show that the net flux of carbon from deforestation will range from values close to those of 1980 to values as high as the current emissions of carbon from fossil fuels, about 5 BMT per year (Fig. 2). The abrupt reductions in the annual releases of carbon shown in Fig. 2 occur when forests have been eliminated in one or more of the tropical regions. Under current trends the elimination of forests in Latin America and Asia can be expected by the middle to end of next century. Once the forests are gone, no further releases of carbon from deforestation are possible from these regions. The total release of carbon to the atmosphere over the next 100 years, if the rates of deforestation in 1980 continue or increase in the future, is calculated to be between 120 and 335 BMT.

If deforestation were to cease, and to be replaced by massive reforestation, the flux of carbon would be reversed. Projections of reforestation show that 100 to 150 BMT carbon could be withdrawn from the atmosphere and stored in new forests over the next 100 years. The maximum removal of carbon from the atmosphere might reach 3 BMT per year. The area available for this reforestation in the tropics is estimated to be 500 to 865 million ha. This area is from one half the size of the U.S. to almost full size.

Such reforestation, however, withdraws carbon from the atmosphere only for as long as the forests are growing and gaining mass. After maturity, forests are approximately in balance with respect to carbon, neither accumulating nor releasing it. On the other hand, reforestation could reduce the emissions of CO_2 to the atmosphere indefinitely if wood fuels were to replace fossil fuels.

The area in forests required to produce annually the amount of wood energy equivalent to the worldwide use of fossil fuels in 1980 is on the order of 500 to 1000 million ha, approximately the area estimated to be available for new forests in the tropics. An area of 500 million ha is about one third the size of the world area of croplands, and about one fifth the area of tropical forests. The prospect of managing such areas of forests sustainably is sobering.

Policies to stabilize the concentration of CO₂ in the atmosphere, if the stabilization is to last into the indefinite future, must include a reduction of fossil fuel use, a cessation of deforestation, and an initiation of reforestation. Of course, the balance between these three measures must take into account the needs for lands and ecosystems other than as defined from the perspective of the global carbon cycle. Furthermore, despite the emphasis here on the tropics, the measures are at least as appropriate and important in the temperate and boreal countries of the world. These countries are responsible for about 75% of the emissions of carbon from fossil fuels. They contain about half of the world's forests and large areas that could be used either for reforestation or the production of fuelwood.

Each of the measures for reducing emissions of CO₂ is good for reasons quite apart from climatic change. An improvement in the efficiency of energy use, for example, whether fossil or wood energy, would not only reduce the emissions of CO₂. It would also reduce the emissions of sulfur and nitrogen oxides, reduce acid deposition, help restore the balance of payments for many nations, and help reduce the international tension associated with purchase of oil from a limited market. Halting deforestation would help maintain the genetic diversity of the planet, reduce erosion, stabilize local and regional climates, and cleanse water and air. Steps taken to reduce one problem help to reduce others. Finally, substitution of renewable energy for fossil fuel satisfies the long-term need to consume no more than can be produced.

In summary, there are three strategies for the use of forests in the tropics (Table 3). The first strategy is "business as usual." Under this strategy, tropical forests may be eliminated from the earth in the next 50 to 100 years, releasing 120 to 335 Pg C to the atmosphere. A second strategy, based on the withdrawal of carbon from the atmosphere, includes a cessation of deforestation and massive reforestation, estimated to be possible on 865 million ha of tropical lands. On the order of 1.5 Pg C yr⁻¹ might be withdrawn from the atmosphere over the next century. The larger the forests, the more carbon that could be stored under this strategy, but the removal of carbon from the atmosphere would continue only as long as the forests were growing. Only the third strategy provides a potentially permanent solution to stabilizing the concentration of CO₂ in the atmosphere. This strategy is based on the substitution of wood fuels for fossil fuels and provides a renewable and sustainable energy base.

Table 3. The annual net flux of carbon to the atmosphere (BMT of carbon per year) under different strategies of tropical forest management.

	Strategy		
	1	2	3
	Current land use practices	Reforestation to accumulate carbon on land	Plantations to replace fossil fuels with wood fuels
Fossil fuel	5.6	5.6	0
Deforestation	0.4 to 2.5	0	0
Reforestation	0	-1.5 (avg.)	0
Plantations	-0.03 to -0.11	0	0 ¹
Total release of carbon to the atmosphere (BMT per year)	6 to 8	4	0

¹ 6.9 BMT carbon released annually from the combustion of 15 X 10⁹ t wood, and 6.9 BMT carbon accumulated annually in 500 million ha growing plantations (see text).

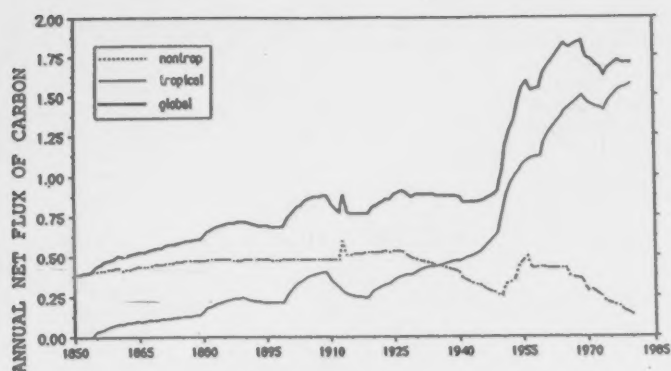


Figure 1. Annual net flux of carbon to the atmosphere from deforestation in the tropics (thin line) and in the temperate and boreal zones (broken line). Flux is in BMT carbon per year.

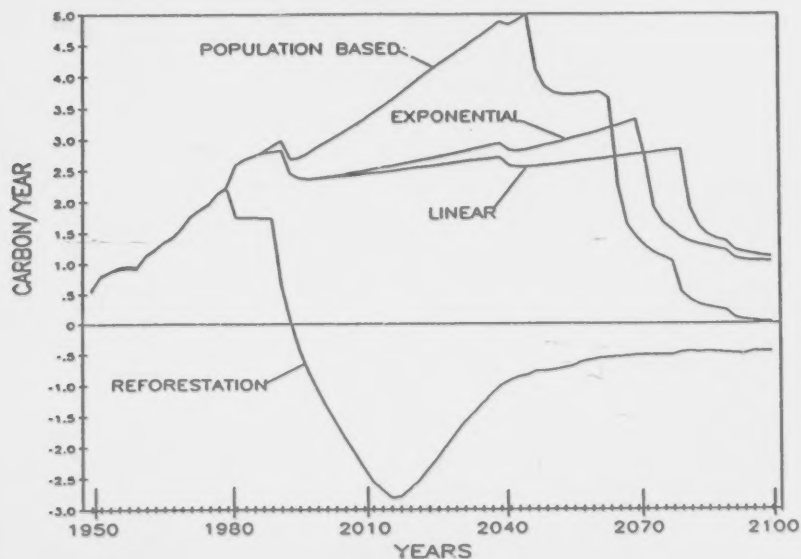


Figure 2. Projections of the annual net flux of carbon (BMT per year) according to different assumptions about deforestation and reforestation in the future.

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STATEMENT OF DR. ALLAN TERAMURA, Ph.D., ACTING CHAIRMAN,
BOTANY DEPARTMENT, UNIVERSITY OF MARYLAND

Senator LEAHY. Dr. Teramura.

Dr. TERAMURA. Thank you.

Mr. Chairman, members of the committee, my name is Allan Teramura. I am a professor and acting chairman of the Department of Botany at the University of Maryland.

I have also submitted a written statement and request that it be entered into the record.

Senator LEAHY. It will be.

Dr. TERAMURA. I have been performing field studies on the impacts of climate change on plants, primarily crops, for the past 15 years or so. During the past year I have been developing a research program, in collaboration with scientists at the International Rice Research Institute at Los Banos in the Philippines, to try to examine what impacts global climate change may have upon tropical rice ecosystems.

I am appearing before you today to outline what I believe are the potential impacts of climate change upon rice production and what efforts need to be begun in order to minimize these potential impacts.

Climate change may potentially be catastrophic for rice production due to several intersecting factors. One of these is that in terms of human nutrition, rice is the most important crop plant in the world.

Second, rice is important in maintaining self-sufficiency for food production in many developing countries.

Third, rice is vulnerable to high temperatures.

And fourth, large temperature increases are predicted for many rice-growing regions of the world.

I want to show you by way of the first slide the importance of rice to the world food supply. Roughly one-half the people in the world today derive over two-thirds of their calories from rice; 90 percent of the people in some of these countries, like Bangladesh, for instance, are totally dependent upon rice.

The greatest producers of rice are also the greatest consumers of rice. And that provides some degree of self-sufficiency in food production.

Rice production may be greatly impacted by global warming. We have evidence, both experimental evidence in addition to past agriculture experience, observations that farmers notice in the field, that indicate that high temperatures have adverse effects upon rice production.

The most dramatic of these effects, and probably the most direct of these is the effect of high temperature upon rice fertility, as shown in this slide here.

I show in this slide two cultivars, which represent extremes in the response to temperature. On the vertical axis we have fertility and on the horizontal axis we have changes in daytime temperature. Note that in both cultivars, the optimum temperature for growth and fertility, and fertility is roughly equivalent to yield, is at 30 °C; that converts to 85 °F. As temperatures approach 35 °C we see that in high-temperature-sensitive varieties of rice, that yield plummets. It falls to about 10 percent of maximum.

However, in high-temperature-resistant varieties of rice, we see that yield is little affected by temperatures of 35 °C. Now, what happens as temperatures approach 40 °C. Then we see dramatic decreases even in high-temperature-resistant varieties of rice. And, in fact, at 41 °C, yield drops to zero even in high-temperature varieties of rice.

Most of our modern rice that is currently grown in the world today has a sensitivity somewhere between these two extremes. Therefore, this temperature range between 35 and 40 °C is extremely critical to rice production in the world and potentially could have catastrophic effects.

To put these temperature ranges into some sort of perspective for you, I would like to show you this next slide. The bottom green curve shows you the daily temperatures in a major rice-growing region in India. This is Cuttack, India, roughly at the same latitude as Hawaii.

This is the current daily mean temperature experienced in Cuttack. Notice that in Cuttack there are two growing seasons for rice, a winter growing season and a summer growing season. Rice flowers at about the same time that seasonal high temperatures are reached in those growing seasons.

The 35 °C line of critical temperature is shown by the yellow straight line. And what it indicates is that even at current temperatures in this region of India, high-temperature-sensitive varieties of rice cannot be grown successfully. What would happen if the global mean temperature increased by 4 °C that is roughly a 7 °F increase? For Cuttack, India, a 4 °C in temperature is illustrated by the red curve.

What you find then, is that in both the winter and summer growing seasons, high temperatures become too warm for high-tempera-

ture-sensitive rice varieties. And, in fact, in the summer harvest period, temperatures approach 40 °C, which means that even high-temperature-resistant rice cannot be grown in Cuttack.

Effectively that would mean that one of the growing seasons in this rice-growing area would be eliminated by a 4 °C temperature rise.

Well, what are the actual predictions for temperature rise in this region? These are data supplied by the Goddard Institute for Space Studies; and these are temperature changes in degrees centigrade during the wintertime.

If you notice just south and to the right of Delhi, India, on the left-hand sector of this graph, you will see Cuttack. And in Cuttack during the wintertime, the GISS model for CO₂ doubling predicts a 3 °C increase in temperature.

During the summer months it predicts a 4 to 5 °C increase in temperature.

I would also like you to note that in certain interior or continental portions of countries like China, the model predicts temperature increases on the order of 6 to 7 °C.

What this means, then, is that relative to the scenario we projected earlier, that the red line represents what our current models predict, or project, for temperature changes in Cuttack, India, again underscoring, I believe, the seriousness of the impacts of increased temperatures.

Well, these are direct effects on rice. In addition to these direct effects, there are other what we might call indirect effects. For instance, we know that increased ultraviolet radiation from ozone depletion seriously reduces crop yields in some plants. It may have a significant, but yet unknown, reduction in yield in rice as well.

Furthermore, the increase in temperature is going to cause an increase in the activity of the hydrologic cycle, the water cycle. That means more evaporation, resulting in more precipitation. This precipitation, however, is not going to be evenly distributed. So that means some areas are going to become wetter, some areas are going to become drier. Those wetter regions then are potentially areas where there may be increased difficulty in both planting rice as well as harvesting rice.

In drier regions drought may become a predominant factor in limiting yield.

We know that the increased temperatures will also increase the severity, the frequency, the duration of storms. Storm damage also severely reduces yield.

The thermal expansion of the oceans' waters will result in sea level rise. During the next century or so it is predicted that sea levels may rise between 1½ to 6 feet.

For perspective, a 6-foot sea level rise for a country like Bangladesh would result in a flooding of about one-fifth of that country. And you will recall that 90 percent of the people in Bangladesh are totally dependent upon rice.

Not only will Bangladesh suffer, but many other coastal, low-lying areas where rice is currently being grown in tropical and subtropical regions, will find that they will have reduced land area for rice production.

Then finally, as we have these changes in climates occurring, there could be subtle shifts in how these plants, that is rice, responds to different pests and diseases.

In addition to rice, a number of other crops are also similarly affected by high temperatures; these include wheat, corn, sorghum, and soybeans. Unfortunately for the developing countries, many of these same crops are also alternate or secondary crops for their food production.

So this is what I call the double whammy of global climate change for rice-growing regions. Not only will increased temperatures reduce domestic supplies of rice production, but it will also reduce the supplies of alternate or secondary crops, therefore, severely minimizing the potential options the developing countries have for alternative sources of food.

What needs to be done? Currently we know that both CO₂ and temperature will increase concomitantly in the future. However, what we do not know is what their combined or simultaneous effect will be upon rice production. CO₂ may either exacerbate or ameliorate the damage.

So we really need to test high-temperature-sensitive cultivars of rice immediately. We need to also examine economically important cultivars of rice. We need to begin developing breeding strategies for high-temperature tolerance. And we need to begin to understand what the geographic variation in high-temperature impacts will be on global agriculture.

And finally, I want to say that funding is essential to begin immediately. And the reason for this is that field experiments take time to set up; they take time to perform; they take time to analyze the data; they take time to disseminate the conclusions of those field experiments.

PREPARED STATEMENT

This work needs to be done not by individuals, but by a critical mass of collective expertise, in multidisciplinary studies. We need crop physiologists, meteorologists, microbiologists, breeders, all working together on the common problem. And obviously it is important to involve international rice research institutes, since these institutes have these core expertise and these institutes are located in those areas that are to be impacted by global climate change.

Thank you.

Senator LEAHY. Thank you very much.

[The statement follows:]

STATEMENT OF ALAN H. TERAMURA

Mr. Chairman, members of the Committee, my name is Alan Teramura. I am the Acting Chairman of the Department of Botany at the University of Maryland. I have been performing field investigations on the effects of climate change on plants for over fifteen years, and I have spent the last year working on a research program to look specifically at the affects of climate change on rice. This effort is coordinated with the International Rice Research Institute in the Philippines. I am appearing before you today to outline the potential effect global warming may have on rice production and, therefore, on food supplies for many of the world's people. I will also outline what efforts should be initiated now to mitigate this situation.

EFFECTS OF GLOBAL WARMING ON RICE

The Earth's atmosphere is changing at an unprecedented rate due to increasing concentrations of greenhouse gases. As a result of the emissions of these gases to date, we will experience some changes in temperature and other climatological factors. These will occur even with stringent efforts to limit future emissions. These changes will be larger with each year that passes without substantial reductions in emissions. These changes will include higher temperatures, different precipitation patterns, and increased frequencies and severity of storms, and will likely lead to climatic regimes outside of recent experience. As these changes occur in major crop growing areas, they will potentially interfere with the world supply of food and the agricultural self reliance of many countries, in addition to causing regional economic havoc.

Rice is an example of a possibly catastrophic situation. This is due to a combination of several key factors:

- (1) the importance of rice as a major source of nutrition;

- (2) the importance of rice to countries developing and maintaining self reliance;
- (3) the vulnerability of rice to higher temperatures; and
- (4) the magnitude of temperature increases predicted for rice growing regions.

These factors are discussed below, followed by the studies needed to better understand the risks that global warming may be presenting for world rice yields.

Rice supplies 2.7 billion people with more than 70 percent of their calories. These people are in countries such as Bangladesh, Burma, China, India, and Indonesia. The people consuming the rice are also the primary producers of rice (the producers are shown in Exhibit 1); rice not only sustains the people of these countries but provides the ability of many of them to be self reliant in food crops. These countries have very limited ability to purchase alternative food supplies if their domestic crops fail.

Rice yields may be severely reduced due to increased temperatures associated with global warming. Experimental results, in addition to past agricultural experience, show that higher temperatures may have several adverse effects on rice. Perhaps the most dramatic effect is sterility induced by high temperatures during the flowering stage (Exhibit 2). While the critical temperatures which affect fertility vary for different cultivars of rice, experiments show that the fertility of some temperature tolerant cultivars are reduced by as much as 70 percent when daytime temperatures are around 40 °C (102 °F). The fertility of cultivars which are not tolerant, but are sensitive to high temperatures may be drastically reduced at daytime temperatures of 34 or 35 °C (93 to 95 °F).

Higher night temperatures also affect rice yields. Higher night temperatures during the ripening phase of the rice alter the grain filling process and produce rice grains with reduced weights.

Given these potential adverse effects, we need to examine the temperatures under which rice is currently being grown and the extent to which these temperatures will likely rise. While a comprehensive study of daytime temperatures in southeast Asia has not been performed at this point, we can examine some representative areas. In Cuttack, India for example (Exhibit 3), the summer rice crop flowers in late September to early October when daytime temperatures are 30 to 32 °C (86 to 90 °F), well below the 35 °C (95 °F) level which is critical for temperature sensitive cultivars. The winter crop, however, is flowering in March and April when daytime temperatures are 36 to 38 °C (97 to 100 °C). These conditions are already suboptimal for cultivars which are sensitive to high temperatures.

If there were a 4 °C (7 °F) temperature increase at Cuttack, India, neither summer nor winter would be suitable for sensitive cultivars, and winter would not even be suitable for temperature tolerant cultivars. Similar situations, with at least one of the growing seasons becoming inhospitable for rice cultivation may be found in countries such as the Philippines, China, and Bangladesh.

An increase of approximately 4 degrees centigrade is being predicted in the Cuttack, India area and in other nearby rice producing regions. The increases in temperature for Cuttack predicted by the Goddard Institute for Space Studies (GISS) model under a doubled CO₂ environment are 3.3 °C for winter months (Exhibit 4) and 4.7 °C for summer months (Exhibit 5). The predicted increases in temperature for China, Bangladesh, and the Philippines are similar, with even greater increases in some cases, such as 6 to 7 °C.

In addition to the effect of temperature on rice yields, there are other factors that will change due to global warming. These factors could act in conjunction with higher temperatures to worsen the situation for rice even further. For example, increased ultraviolet radiation due to ozone depletion may add unknown stresses to plant systems. Rainfall patterns are also expected to change. As a result, rice could be subjected to droughts with increased frequency; the monsoons could develop at sea as usual, but not come inland and provide necessary rainfall. Alternatively, the rainy period could be extended making planting difficult. With higher temperatures, this could set up an environment for a host of new pests. In addition, sea level rise and salt water intrusion may greatly reduce the amount of land available for rice cultivation. Studies indicate that a two meter rise in sea level would inundate 20 percent of Bangladesh (Titus, J.G., 1986).

In addition to rice, similar relationships between global warming and crop yields exist for a number of other major grains. These include wheat, maize, soybeans, and sorghum. After rice, wheat is next in importance as a major source of food for people of southeast Asia; maize follows wheat (FAO, 1980). Some specific effects of global warming on these crops are provided in Exhibit 6. Since approximately the same high temperatures that affect rice crops will also affect these crops, these other grains represent further risk to food security in southeast Asia, instead of less risk.

NECESSARY EFFORTS

Understanding the potential risks that global warming is presenting to agriculture is important to formulating programs to mitigate these effects. Due to the multitude of factors that will change and their complex relationships, there is currently great uncertainty in what the potential effects on agriculture will actually be. Among, the various possible outcomes are ones

that are even worse than those currently indicated. We need to know now what the potential are for rice production.

TO understand the potential effects of global warming on rice, we need to:

1. Investigate the effects of simultaneously higher temperature and carbon dioxide on temperature tolerant rice cultivars.

Increased carbon dioxide may either act to exacerbate the effects observed from high temperatures alone or to moderate these effects. No information is available on how these factors jointly affect rice yields under field conditions. To understand the magnitude of the potential risks, information is first needed on those cultivars expected to be most resistant to temperature increases.

2. Investigate the effects of simultaneously higher temperature and carbon dioxide on the most economically important cultivars of rice.

A variety of cultivars are grown throughout southeast Asia and are of large economic importance. These include cultivars with varying degrees of sensitivity to temperature. We need to understand the potential risk to these cultivars.

3. Determine magnitudes of potential losses at different locations for predicted increases in temperature and carbon dioxide.

Effects will vary from location to location, depending on such factors as soils, length of daylight and

intensity of solar radiation. Accurate information is needed on the potential effects in these areas. Information on the areas with largest potential losses is necessary for the development of mitigation options.

4. Determine potential for breeding tolerance, if present, into high yielding, pest tolerant cultivars.

A primary mitigation option may be breeding cultivars which are tolerant to globally warmed conditions. Breeding programs are currently well developed for generating cultivars which are high-yielding, resistant to drought, or resistant to a variety of pests. We need to determine the genetic basis for temperature tolerance and to incorporate temperature tolerance in cultivars which have these other desirable traits.

These studies need to be initiated in the near term. This is because it takes years to set up, perform and validate field experiments and to then incorporate the results into breeding programs. The breeding process alone can take on the order of ten years for development, testing, and distribution of a cultivar. These studies must be performed at a variety of locations by groups experienced in growing and developing rice cultivars such as international rice research centers. These centers will provide additional expertise with other adverse factors such as water management, fertilizer use, plant pests and diseases.

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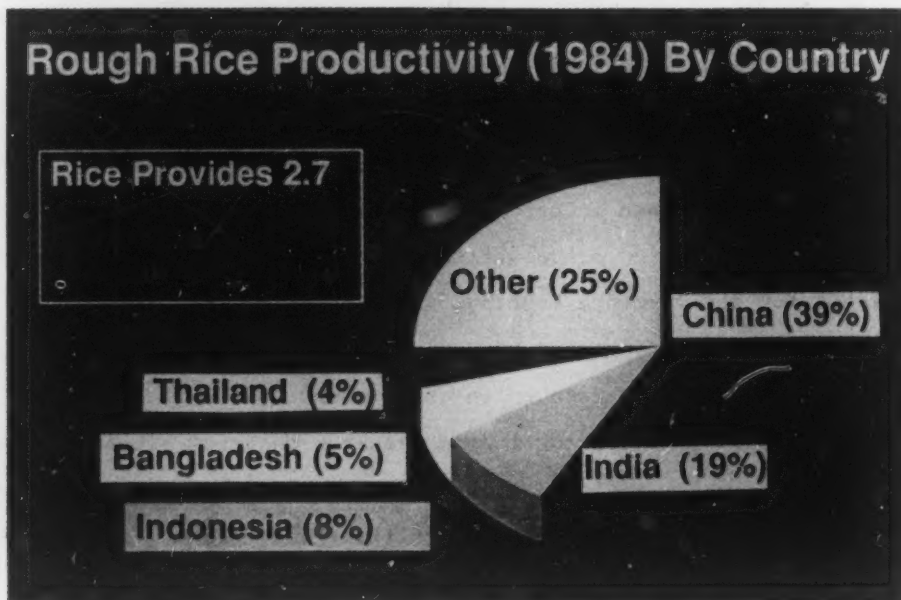


EXHIBIT 1.

Rice and Temperature

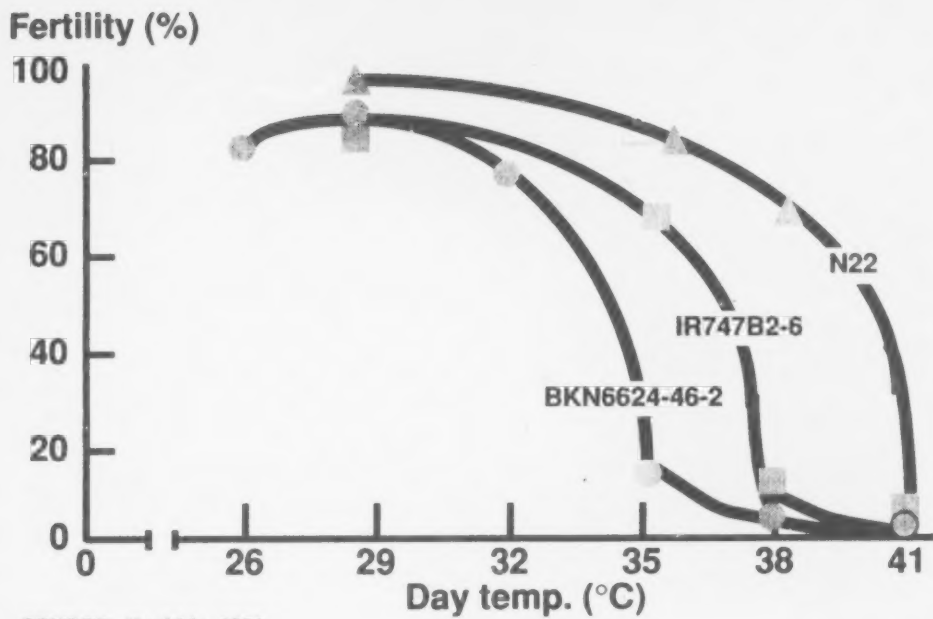


EXHIBIT 2.

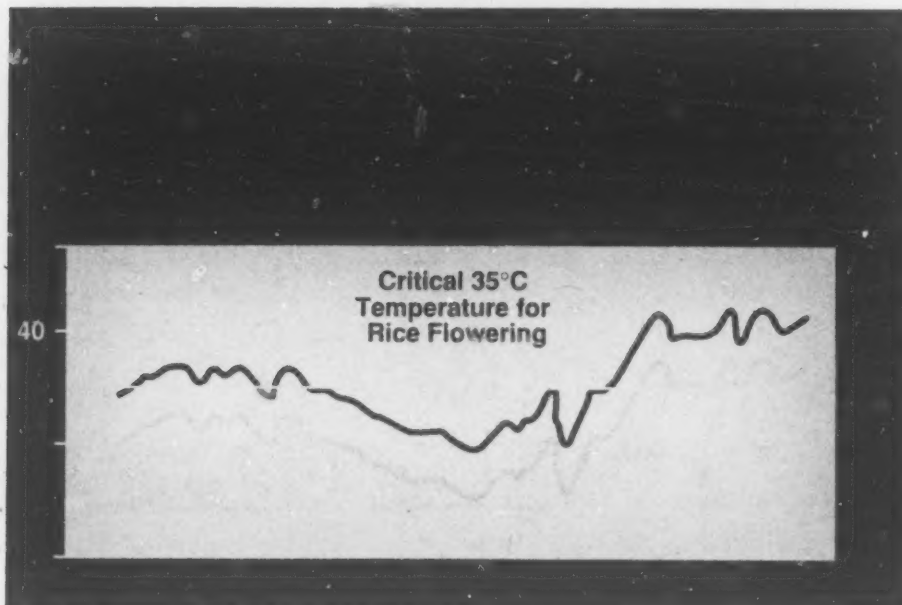


EXHIBIT 3.

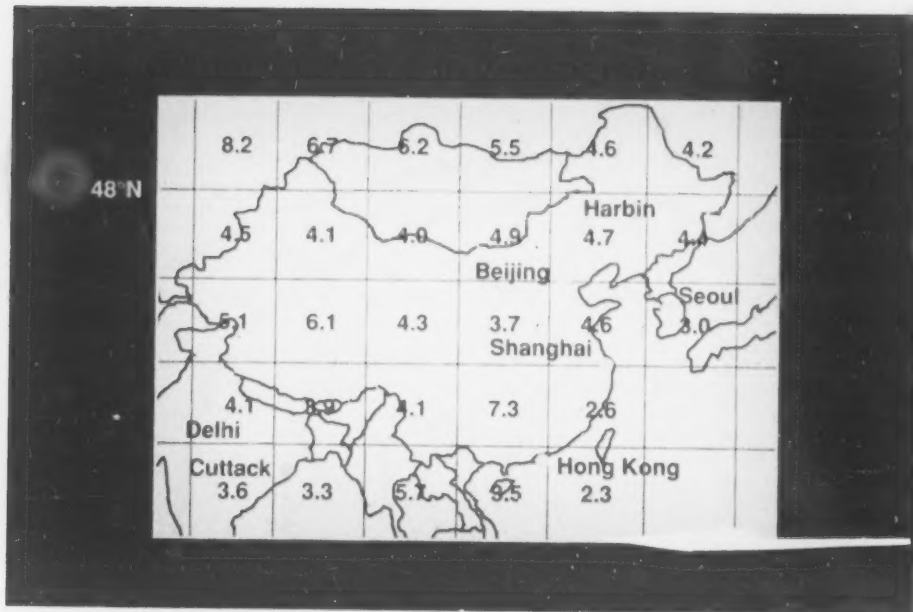


EXHIBIT 4.



EXHIBIT 5.

Many Crops May Be Similarly Influenced

- Wheat shows reduced yields at daytime temperatures of 30°C during ripening
- Maize experiences reduced pollen germination above 32°C
- Sorghum shows reduced yields from temperatures of 33°C during growth stages
- Soybeans are of inferior quality when they mature during hot conditions (> 32°C)

EXHIBIT 6.

GLOBAL WARMING AND THE THIRD WORLD

Senator LEAHY. Let me begin with Dr. Riebsame. A lot of people—if you read some of the op-ed pieces and whatnot—act as though they think that global warming is an issue in which the Third World has very little at stake. But your testimony says just the opposite; that many of the countries could be severely impacted in several ways: droughts, floods, freezes, vulnerability of food, some loss of resiliency to change.

It would appear to me, then, that the Third World does have a lot to lose from global warming and climate change; is that basically the way you feel?

Dr. RIEBSAME. I could not agree with you more. That is why I am suggesting that we need to know more about how resilient these societies are in the face of rapid climate change.

Senator LEAHY. You work with some of these countries, you talk to them and so on. How do people respond to the global warming issue? Do they believe it is real?

Dr. RIEBSAME. That is an important question right now. As you know, we have heard comments here that we ought to be more involved in the international negotiations. I can tell you that there is a great skepticism about the issue, especially in the developing world. And, in fact, it is beginning to look a little bit like an us and them problem. We are telling them that there is a big problem. And they view that as an attempt to gain power over their development trajectory.

I am not a great geopolitical strategist, but I think we need to be aware of the backlash that I see occurring in the developing countries. And my own modest proposal is that we simply need to help researchers and resource planners in the Third World learn for themselves, through their own analyses, what climate change may

mean to their own food security and their other natural resource security. That is how we are going to be able to create a better awareness of the issue.

It does not always work for us to do the analysis and then just go tell other people that it is a big deal.

U.S. AGENCIES AND GLOBAL WARMING

Senator LEAHY. Are we actually asking these same questions of ourselves? I mean, we want to give advice to the Third World, and perhaps provide some of the expertise, but are we doing the same thing here? For example, should the Department of Agriculture and the Forest Service be asking some of these same questions, and are they?

Dr. RIEBSAME. No; not seriously. I think that a lot of people are talking about it. I have suggested that we need to be assessing the greenhouse sensitivities, if you will, both in terms of how our activities impact the greenhouse effect and how they may be impacted by climate change. I feel that this need also applies domestically.

The three questions that I suggested in my testimony are an explicit attempt to get us out of the starting gate on the issue; so that we can get around the wait-and-see attitude taken by the agencies because there are so many uncertainties.

My questions accept those uncertainties and try to work with them. I believe that if they are asked, as we plan our forests, grazing lands, and agricultural programs in this country, that good planners will start to see the problem and begin to deal with it.

Senator LEAHY. I appreciate that. But I sometimes criticize the Department of Defense for doing its planning on how they would reflight World War II. We would be a lot better prepared if we had to reflight World War II. Unfortunately that is not the reality.

But I see the same thing in the Department of Agriculture and the Forest Service. It is very comfortable to look back at those things in the 1940's, 1950's, and 1960's and sort of reinvent the wheel or the planning. But I looked at the Forest Service 50-year planning document, the so-called RPA assessment; it did not even mention the possibility of climate change, much less what we should plan to do about it. And this is when you are talking about forests that cannot be changed each year like seasonal crops can.

And I thought that, considering all we have heard about global warming, this is remarkably short-sighted, and I passed on my feelings in as direct a way as we might in Vermont.

But keep on speaking out, all of you, because sooner or later they will start listening.

IMPACT ON FOOD PRODUCTION

Dr. Teramura, I know what you say about rice is significant. In many ways it is a complete reversal of the green revolution we saw in the past. Is that an overstatement? Are we getting toward that area?

Dr. TERAMURA. Well, it could be that many of the advances that are provided for by the green revolution could, in fact, be retracted

by global warming and the events associated with it, like sea level rise and the other events.

Senator LEAHY. But you said one-half the world could go hungry if rice production was disrupted, is that correct?

Dr. TERAMURA. Yes; over one-half the world would go hungry if rice production was disrupted.

Senator LEAHY. I think that listening to this testimony, that is one of the things that concerns me the most. We are in a country where—certainly those of us who are policymakers—if we ever go hungry, we go hungry only by choice. And yet we are seeing what has happened with hunger in our Nation—millions of people hungry. As I have said over and over again, it goes above being a social or political issue, it become a moral issue. But even that hunger is a lot different than what I have seen in some of the Third World areas.

Do you think that we here in the United States are doing enough to learn about the potential consequences of global warming for Third World nations?

Dr. TERAMURA. Absolutely not. Currently there are well-developed breeding programs, for instance, to try to understand or mitigate the impacts of drought on crop yields. There are existing programs on mitigating the impacts of disease on yield. But nowhere are there any studies examining the impacts of high temperature on yield.

There also are no studies which have examined the combined effects of increased CO₂ and temperature on rice yield, despite the fact that there is a potential catastrophe looming in the future.

Senator LEAHY. Thank you very much.

DEFORESTATION

Dr. Houghton, do you think we are doing enough to understand the effects of deforestation—in some ways related to the question I just asked Dr. Teramura—but in the areas of deforestation? Are we doing enough to really understand the effects of that in this country?

Dr. HOUGHTON. No; I do not think so. Besides the contribution of deforestation to the increase in atmospheric carbon dioxide, deforestation also affects local climate. Forests stabilize soil, contribute water vapor to the atmosphere, affect the amount and quality of water in rivers, modify local temperature, and provide a number of other public service functions. We know some of these services qualitatively, but our knowledge of how much local or regional climate is changed as a result of deforestation is quite poor. We hear arguments that the loss of trees in the Sahel, for example, has contributed to desertification there. There is much more to be learned, however, about the extent of this contribution and how it pertains to other climatic zones including the United States.

I would also like to respond by saying that we know the rate of tropical deforestation very poorly considering its importance to the global climate and the demonstrated ability of satellite technology to measure it quite accurately. I want to point out that there have been no estimates of deforestation for the whole tropics since 1980.

Most people assume the rate of deforestation has not changed that much since 1980, but in the places we have looked, it has.

Senator LEAHY. And in some places it is changing rapidly.

Dr. HOUGHTON. Very rapidly. And the point is there are many places where we have not looked. And even in 1980 the question of accuracy exists. I think there is great uncertainty there with respect to rates of deforestation.

The technology exists, however, for looking, relatively cheaply, at the whole world's forests, and monitoring the changes in area. Nothing like that is underway that I know of, either internationally or within States.

Senator LEAHY. Senator Gorton?

USE OF WOOD PRODUCTS

Senator GORTON. I think Senator Boschwitz left you a written question there, which I noticed that you were studying a little bit. I would appreciate your comments on that question, but perhaps I can make it a little bit more precise. You informed us of the tremendous additional concentrations of CO₂ due to tropical deforestation with almost no reforestation going on.

If I heard you correctly, you said that it was your view that outside the tropics it is about a wash. What is lost through deforestation is being gained through reforestation. I wonder if you can break that down a little bit more precisely? Say whether or not that statement applies just generally outside the tropics or whether it applies specifically here in the United States, and to what extent do we have either a plus or a minus in connection with global warming, depending on the use of forest products?

I believe that you also said that we would probably have a net gain if we used more wood for burning and reforesting than say, coal or something of the sort. But is there a difference as to whether or not we use products (1) for burning; (2) for construction materials as a part of our homes; (3) for wood pulp to make, to produce newsprint or the like as against reforestation; and (4) what is the impact of cutting and using forest products and replanting the same area as again, simply preserving old and mature trees?

I know I put a bunch of questions in that, but it is sort of like a general explanation of your views.

Dr. HOUGHTON. Well, in response to the first question, the simplest answer is that outside the tropics, both the region as a whole and each nation by itself, the United States, the Soviet Union, Europe, China are close to balanced with respect to a flux of carbon. Whatever the exchanges of carbon are, they are small in comparison to what is happening now in the tropics. I should add that particularly for the Soviet Union and China, there is quite a bit of uncertainty as to whether there is a net deforestation or net reforestation. We hear of reforestation in China, but the success rate and the rate of deforestation there are not well documented.

Let me answer the other questions in a more general way. If you were to log a forest and then let it regrow, and if it were to regrow back to the same carbon stocks it had originally, then, theoretically, over the long term there would be no net exchange of carbon dioxide. In the short term, there would probably be a release fol-

lowed by an accumulation of carbon back on land, because forests generally decay more rapidly than they regrow.

Practically, however, forests that are logged are rarely allowed to grow back to their original stocks. In managed forests the average standing stocks of carbon are considerably less than the stocks in mature forests. So the harvest and management of old-growth forests releases carbon to the atmosphere even if the harvest is followed by regrowth.

Carbon is, of course, stored in forest products. If the products are lumber and other long-lasting materials, they hold carbon out of the atmosphere longer than paper products. But relatively little, as I understand it, of what is standing in a forest is incorporated in long-lasting products. Branches, leaves, stumps, and roots are left to decay on the forest floor, and sawdust and other wastes are generated at both the mill and the site of wood use.

Senator GORTON. So only the long-term use, say in housing, that would restore carbon dioxide?

Dr. HOUGHTON. That is correct only if those same forests were allowed to regrow again to their original stocks of carbon. Such is the case for secondary forests—those already managed—but not for old-growth forests. I think the U.S. policy should be not to cut old-growth forests. Logging should be restricted to forests that have already been logged. Did I answer all your questions?

Senator GORTON. I think you did. So, you would more or less equate the actual use of wood products for burning for producing heat with, say, pulp for paper because both or one may be a little bit more short term than the other, both are short term and all the carbon is going to be discharged in a relatively short period of time?

Dr. HOUGHTON. Yes; that is correct.

Senator GORTON. What happens in the mature forest?

Dr. HOUGHTON. In the mature forest there is no net exchange of carbon dioxide. It is pretty much in balance. During the day, carbon dioxide is taken up in photosynthesis, but during the night, it is released again in respiration. So over the course of a year, it is pretty much in balance.

Senator GORTON. Thank you. Thank you, Mr. Chairman.

Senator LEAHY. Thank you very much. Senator Kerrey?

GRASPING THE ISSUE

Senator KERREY. Mr. Chairman, first of all I would call attention to something that I consider to be noteworthy. And that is that this hearing is being jointly conducted through the Committees on Agriculture and Foreign Operations. It seems to me that there is a connection as well between that and the fact that we are considering something in a global way without any concern about being accused of being too fuzzy headed.

I also must point out that—I mean all three of you are scientists—and I must confess that there is an awful lot of about what you are saying, particularly in the detail of your report that I just simply do not understand. And I must also confess that the global warming issue itself reminds me of something that use to happen to me, practically every spring. And that is that I would come in

and discover that an afternoon out and about in the woods had produced a rash and that I had picked up poison ivy someplace and I did not know where it came from.

I feel now like I have this global warming itch, and I do not know where it came from. It seems to me that one of the beginning points of analysis for me is that I try to figure out what we should do. So I try to get a sense of what the problem is and then try to describe or listen to others describe solutions and try to decide whether or not I think that solution is appropriate.

One of the best starting points, in addition to that sort of short-term reactive measures, whether it is deforestation in the tropics or whether it is trying to respond to some already-warming conditions that we see in Asia that could have a terribly adverse impact upon those peoples' capacity to produce food and feed themselves, in addition to short-term reactive measures that are obviously needed, one of the starting points should be here at home.

WASTE GENERATION

And I would just like to ask the panel are we or are we not the world leaders in generating waste? And are we or are we not in the United States of America regarded throughout the world as the leading nation in waste generation?

Dr. HOUGHTON. I think so. With respect to generating carbon dioxide, it is clear the United States is generating more than other countries. But most of that, again, has not to do with deforestation, but with energy use. So I think if energy use accounts for 75 percent or so of the total carbon dioxide emissions, that is where the biggest change must occur. That is where you are going to have the largest effect.

I would also like to tell of a meeting in New Delhi, India, recently, where we addressed global warming from the perspective of developing countries. The response of this Third World community was generally, "we agree that global warming has important ramifications for us, for India. But before you can expect us to do much about it in terms of either our energy use or deforestation/reforestation, we would like to see an example. We would like to see that you in the United States are taking it seriously enough to do something yourselves."

Dr. RIEBSAME. I do not think that there is any doubt that we are, of course, one of the most consuming societies in the world. We have to recognize one thing. What Dr. Houghton just said is important. There is, Senator, a sense in the Third World that an example needs to be set. But I would just add that we are going to have to recognize in the future that Third World countries may be the big contributor, say for instance, of methanes from rice production.

And methane is actually the most rapidly increasing greenhouse gas right now. And in the future, methane could really be—is kind of a wild card in the system. And thus, while we can certainly set an example, we are not going to be able to fix the problems ourselves.

Dr. TERAMURA. I would like to just comment, add a little bit about this methane issues as well, and that is that the reason why rice is such a critical crop to study is that not only is it impacted

by global climate change, global warming, but rice itself may cause global climate change. By that, I mean that the estimates we have today seem to suggest that somewhere between 20 and as much as 30 percent of all the methane emitted into the atmosphere today, comes from rice patties.

Methane is at least one, and possibly several orders of magnitude more of a greenhouse gas than a CO₂. Because methane has a short half-life, we can, by small reductions in its emissions, stabilize methane increases in the atmosphere. If we can examine the causes of methane flux in rice patties, develop potential alternate cultural practices to reduce those methane fluxes, we, in effect, could stabilize methane emissions. At least that is a possibility because of the very short half-life of methane and because of the fact that it is extremely, extremely reactive as a greenhouse gas.

Senator KERREY. I do not want to suggest that there is not at least, by my way of thinking, a new maturity in the United States toward the amount of waste that we generate and a new maturity between ourselves and the environment. But even at home, for example, we have a very difficult environmental issue between the developmental interests. The city of Denver, which is trying to provide for its water, as you know, trying to provide for its water needs over the next 20 or 30 years by proposing the impoundment of 1.2 million acre feet of water on the Platte River, downstream as well as the upstream basin. And there is concern about the impact on the environment. I do not want to get into the details of it, but one sign of a new maturity is that both parties, both the developmental interest and the environmental interest, refer now to the Platte River as an ecosystem. There are still a few hard heads out there who call it a drainage ditch.

But most now use, and it may be for tactical reasons, but nonetheless, it is encouraging to see all of us now referencing the river system as an ecosystem itself. There are not, for me at least, shortages of examples where there is new maturity. But what I am genuinely struggling with, personally, is what should our response be in the area of global warming? I would also, just if you could give me your comments on, your view, since you are all approximately of my generation, your view of the world as it is change in this regards as well?

GLOBAL WARMING IS NEW PRINCIPAL THREAT

It seems to me that as I look at the world at large and the world as we live in today, that for approximately 40 years, we have been identifying the principal threat to the world security as the Soviet Union and world communism. I made a statement the other day that not only does it appear to me in the process of a new grain sale to the Soviet Union that Joseph Stalin is dead, but it appears to me that Joseph McCarthy is dead as well.

And the new threats that we are talking about that you are identifying for us, would enable us to set, not only enable us, require us to set aside ideology. It seems to me that one of the things that I look at is a need for some kind of structure to permit us country to country. And I do not want to get into this issue, should we or should we not have an international conference, but it seems to me

that some sort of structure to discuss these issues, nation to nation, becomes awfully important.

And here, the United States of America, I think, can lead. Not only do we have the experience with democracy and widespread democratic institutions, but we also have a very high level, relative to most, I think, of understanding of scientific issues. Even though I said at the start, I do confess to being sort of bewildered at some of your testimony.

And all I am looking for really, is a personal response as how you see the world today. Where you see the threats today, and what you think our response should be.

Dr. RIEBSAME. I think one of the things that excites people, scientist in particular, is the new integrated look at the environment. You know we are undergoing a plan for an International Geosphere/Biosphere Program [IGBP]. I think it is really exciting that biological and physical scientists are together, but I am also a critic IGBP. I think we have left out the social systems in that work.

We are looking at global ecosystems, but the Platte River and its connection to my home, near Denver, is also a social system as you well know. I think we have left out the social science component. But, yes, we are looking at the environment in an integrated fashion. I think we just realized some fundamental truths that had been sitting there all along. I am a card-caring environmentalist; I admit it.

I want to say one quick thing. The institutions that you referred to that are emerging, the Intergovernmental Panel on Climate Change, which is meeting right now in Geneva, the U.N. environment programs World Climate Impacts Program. They are there and they are gaining slowly some credibility. But they are not all that strong, in my opinion. And I do not think we have the institutions to mount a serious international attack on this issue.

There is a lot going on, many discussions and meetings, for example, in Delhi where Dr. Houghton was just at. But institutions, yet, are not strong enough to really deal with climate change, in my opinion.

Senator KERREY. Let me just follow up a bit and I see a red light. I do not know if it is my red light or yours.

Senator LEAHY. It is yours.

Senator KERREY. Mine. Did you want to get in here?

Senator BOND. Before lunch sometime.

Senator KERREY. OK. We may eat late.

Senator LEAHY. Only because we will have to get the other panel in here.

Senator KERREY. OK. I will follow up personally.

Senator LEAHY. No; go ahead. Take your question. We will give additional time to Senator Bond.

Senator KERREY. You no doubt grew up—I will just get one of you, this presents—Doctor, you are at the microphone. In the late 1940's and the 1950's we saw a need to develop a strong alliance against communism in Europe and against communism worldwide. And we set up all kinds of interrelationships with other countries to confront that real threat.

And I do not want to get off into that too much, but now what I hear coming from, not only this panel, but lots of other people, as

well, is that there is a new threat out there in the world. A different kind of threat that requires a different kind of, in many ways, nonideological alliance. And that is the way I see it and I am just curious as to whether or not you view it the same way?

Dr. RIEBSAME. Since you asked the question on a personal level, I am going to respond on a personal level. I was born in 1953; my consciousness of the world does not include a lot of what you addressed that went on beforehand. And that may make me naive, and it certainly shaped the way I look at the issues.

For instance, my call for international cooperation on the global change issue, may be a little bit naive. All I can say to that is no contest by virtue of birth date.

Senator LEAHY. Senator Bond.

NUCLEAR POWER

Senator BOND. Thank you, Mr. Chairman. I want to thank the panel for a very interesting and stimulating discussion. I would like to follow up on Senator Kerrey's questions and some of your responses. I get the picture that we are going to have to do something in this country. You talk about the deforestation being a problem in the Third World, but obviously the burning of fossil fuel in the United States is part of the problem. Would nuclear fusion, nuclear fission, as a substitute for fossil fuel lead to a significant reduction in our contribution to the greenhouse effect? Dr. Houghton?

Dr. HOUGHTON. Yes; if you were going to replace fossil fuel with nuclear, you would clearly eliminate almost all of the carbon dioxide emissions from that source. No question there. I guess I am not convinced that nuclear power is the way to proceed. The waste issue is still unresolved, perhaps unresolvable. I would prefer to implement ways of reducing total energy use by using it much more efficiently. I think one can go a long way in that direction.

I think to replace today's use of fossil energy with nuclear energy represents a huge expansion of nuclear power, that is probably not necessary.

Senator BOND. Well, I would ask the other gentleman, Dr. Teramura, do you have any comments on that or Dr. Riebsame?

Dr. TERAMURA. Well, basically, I would agree with that. I would add however, if we switched to nuclear, it is basically a Faustian bargain. I mean, we can clean up air pollution and a lot of water pollution for the short term, but in the long term, then we have another problem that we have to solve. And that is what do we do with solid waste products that have half lives that are greater than the age of the Earth? Very difficult problems to deal with particularly since, in looking at how nuclear byproducts are contained now and reading reports of losses of those nuclear byproducts without any indication where they went to and any way of accounting for them, I think the potential for problems is enormous.

So, certainly, for the short term, if we did switch to something like fission, we can certainly reduce air pollution and many of these problems, but it is a short-term solution.

Senator BOND. Don't we have a problem in the short term? Are we not causing ourselves a major problem right now?

Dr. TERAMURA. We do have a problem in the short term. But again, we must view the ecosystem and the world in a long-term basis. In return for our prosperity for the next 100 years our grandchildren, or their grandchildren are going to have tremendous problems to deal with in the future.

Senator BOND. So you would be willing to accept the continued global warming and thus let everyone in Vermont wear bathing suits?

Dr. TERAMURA. No; I would not.

Senator LEAHY. I want you to know there is at least 1 week a year that we can. [Laughter.]

We have 8 months of winter, 3 months of poor sledding, and 1 month it can go either way.

Senator BOND. I was very much impressed, Mr. Chairman, when we were in Vermont and saw a person with a wonderful tan. And I complimented this person on the wonderful tan. I said you must be getting a lot of sun. He said, no it was rust.

Senator LEAHY. I think your time is up, Senator Bond. [Laughter.]

REFORESTATION AND OTHER OPTIONS FOR UNITED STATES

Senator BOND. Let me go back, without dwelling on, to the question asked about nuclear fusion and fission. I think nuclear fusion and its byproducts are something that we are going to have to consider down the road. I get the sense from you that, and I believe, too, that we are going to have a tough time selling the Third World countries on doing something about global warming unless we do something about it here. My purpose in raising that question is, what are the real options we have to do in this country?

I know the chairman and our friends on Foreign Operations can take care of the rest of the world, but it seems to me that we have a responsibility in this country. In our agricultural programs, should we not be putting an emphasis on reforestation, of conservation lands that are not being used for crops? I think, Dr. Houghton, you indicated that that would be a very small contribution. But what about putting much more emphasis on forestation in our agricultural programs? What about, perhaps, making a major effort, and this obviously will offend a lot of sensibilities and get people riled up, but forestation projects in our deserts?

Shouldn't we be willing as stewards to take these steps ourselves before we ask other countries to do them? And Dr. Riebsame you are talking about the social impacts of these, what are your views on it? I would like to hear the views of the other two panelists as well.

Dr. HOUGHTON. Reforestation can have a significant effect in climates that will naturally support forests. As I understand it, much of the land available in the Conservation Reserve Program is marginal land and would probably not support large forests. Nevertheless, although the effect of the program may not be large in the global sense, it is certainly a step in the right direction that serves as an example that the United States is doing something about the problem. For that reason, I think it is a good program.

I would not recommend forestation in deserts or anywhere that forests were not naturally capable of growing. The energy, irrigation, and fertilizers required to support forests in such areas would generate more carbon dioxide than the growing forests would accumulate. Reforestation should be attempted in those areas which have supported forests in the past and that are not being used now for crops or pastures. There is probably a large area in this country that satisfies these two criteria for reforestation.

Dr. RIEBSAME. I would like to take the question a little bit further and ask the question, well what are the hurdles that we are going to have to get over to start conducting, carbon neutral resources activities in this country? And one of those hurdles is that the issue is still a little fuzzy. There is still a lot of uncertainty.

And we will have to deal with that. We will have to deal with the fact that the Corps of Engineers or the Department of Interior, Bureau of Reclamation, and Bureau of Land Management can sit here and say, look, we are not certain. You are not telling us enough yet, whether or not we really have to do these things. And that is the point of my testimony, that there is something in between waiting and seeing and taking drastic action.

One of the easiest things to suggest is that there are sets of activities, like, for instance, the conservation of reserve properties and what not, that at least start to make a dent in the issue and make sense for other reasons. And that is the simple logic that we are going to be stuck with, in my view, probably for the next several years. This issue is still going to be argued back and forth, and we need to think of the sort of the tripod of logic for each adjustment step, and one of them is reducing greenhouse gases and the other ones are other conservations methods and efforts to reduce climate impacts.

Dr. TERAMURA. I think one of the real problems that face us today, is the fact that in developed countries, often times there are a number of options that one can turn to when faced with the effects of global warming. Whereas in developing countries, their options are very, very limited. And that is why I had been focusing most of my attention toward rice.

Because in most of these rice-growing regions, they have virtually, only a very, very few options for mitigation. And, therefore, I believe that it is important for the United States to begin looking at some critical studies on the greenhouse effects and the impacts on rice production, primarily because this work is not currently being done at all.

RICE BREEDING

Senator BOND. One last quick question. Could genetic engineering or biotechnology assist not only with improving the heat resistance of rice, but, perhaps, reduce the methane escape both?

Dr. TERAMURA. It is very possible that biotechnology could help mitigate the problems. It is one option. I think what we should do really, is to exercise our options in parallel. We should use conventional breeding practices as one option. If there is a genetic factor in high temperature tolerance that we can breed for, that may be one way to go. We may find, in fact, that high temperature toler-

ance cannot be breed for because the genes do not exist in the crops we are studying. In that situation then, only genetic engineering could help us.

We would have to then look in areas where plants grow under high temperatures naturally, identify those genes responsible for the high temperature tolerance, extract and insert them into the desirable crop plants that we wish to have in the future.

Senator BOND. Thank you very much, Mr. Chairman.

Senator LEAHY. Thank you. Senator Baucus did you want to ask a question?

REDUCING LIVESTOCK METHANE

Senator BAUCUS. Yes, Mr. Chairman. Thank you. Dr. Teramura, what is the potential for addressing methane controls by changing livestock feeding, different feeds, and composition of feed to reduce methane? Would you address that briefly?

Dr. TERAMURA. Although that is not an area of expertise for me, I do understand that livestock may account for as much as 15 percent of the total methane emissions into the global atmosphere. And there is some understanding that one of the reasons for this methane production by livestock is as an end product of digestion of plant material. Livestock basically are nitrogen starved, if you will, or nitrogen seems to be one of the more limiting factors for livestock growth.

Therefore, there is a possibility that if you increase the nitrogen content of the feed, you can decrease the total consumption by the livestock for the same amount of growth and weight increment increase. And that alone, may reduce methane emissions from livestock.

Senator BAUCUS. But do you think there is a significant enough potential here to warrant changing feed?

Dr. TERAMURA. The estimates that I have seen seem to suggest that we only need about a 10- to 20-percent reduction in total methane emissions in order to stabilize methane emissions. Right now methane is increasing about 1 percent per year. If livestock contributes 15 percent, we might be able to save, let us say, one-half of that. If we can alter the cultural activities associated with rice cultivation and save another 10 or 15 percent, certainly I think we can flatten out or stabilize methane emissions. It is within the realm of possibility.

Senator BAUCUS. Good. Thank you. Senator Bond, do you have any more questions?

Senator BOND. No; thank you.

Senator BAUCUS. Thank you very much, gentleman, for your testimony.

INTRODUCTION OF PANEL TWO

Senator BAUCUS. Our next panel is Mr. Bissell, Assistant Administrator for Policy and Program Coordination at AID; Dr. Robert Miller, Director of the Department of Soil Sciences, North Carolina State University; and also Dr. Brent Blackwelder.

REMARKS OF SENATOR LEAHY

Senator LEAHY. I appreciate the testimony of the three prior witnesses. Listening to their testimony, I realize that we touched only the surface on a very complex, very important issue. And I appreciate the time you have taken and I want to emphasize again, there may be some other questions for the record, but I would hope that all of the witnesses would look carefully at any responses and feel free to add to them or, if they think of some other items that they feel the committee should see, that they will add to it.

The second panel is here to discuss what the agencies and organizations within the jurisdiction of these two committees are doing now about global warming. We are looking for some specific, practical, legislative and policy proposals these committees might consider to help move this process forward.

I think the time of enjoying the luxury of just being educated on the subject is passing and we are reaching the time where we are actually going to have to respond legislatively. And with us are Richard Bissell, AID Assistant Administrator for Policy and Program Coordination; Dr. Robert Miller, Professor and Director of the Department of Soil Sciences, North Carolina State University; and Brent Blackwelder, the Environment Policy Institute in Washington. And, of course, I appreciate very much your being here. I appreciate your waiting to speak.

OMB CENSORSHIP

Mr. Bissell, I want you to know that this is not directed personally, but in view of the outrageous revelation of censorship by the Office of Management and Budget testimony on global warming, I am going to have to ask you for your assurance that your statement today has not been bowdlerized by OMB bureaucrats for policy reasons. The reason I raise this is not just because most of the people at OMB do not have the foggiest idea what to do about global warming so you kind of wonder why they are getting involved in the first place, but I am especially concerned because I know OMB held up your testimony for this hearing. We only received it, the official testimony, today. Are we hearing your best analysis and advice of what AID could be doing in the global warming area or are we getting script from the White House for feel-good environmentalists?

STATEMENT OF RICHARD BISSELL, ASSISTANT ADMINISTRATOR FOR POLICY AND PROGRAM COORDINATION, AGENCY FOR INTERNATIONAL DEVELOPMENT

Mr. BISSELL. Mr. Chairman, I can honestly say that my testimony was not only not bowdlerized by OMB, but that in fact, the delay was largely our fault. I and my staff have been very preoccupied with many issues, and we only got my statement to OMB yesterday. So they turned it around in remarkably fast time.

Senator LEAHY. Thank you. You are probably not surprised I asked the question.

Mr. BISSELL. I am not surprised at all.

Senator LEAHY. And it is conceivable that they have learned their lesson after the last one.

Everybody is going to be hurt by global warming. As we know, the earlier testimony indicates the Third World and developing countries may have the most to lose. And many of them already live on the edge of survival.

They do not have the resources to adapt to climate change. We have seen that with the famines in sub-Saharan Africa, the severe flooding in Bangladesh, air pollution from burning coal in China. Some of these things I have seen myself on visits.

I want the administration to exercise the leadership that is desperately needed. It has not been exercised in the past. I got very concerned when I heard OMB was afraid to let us hear unvarnished testimony from top government scientists about this urgent problem. I think that is a mistake. And I think worse than that, it sends a very wrong signal to the rest of the world.

I am extremely disturbed that the White House is not supporting the negotiation of a convention on global warming in Geneva this week. President Bush had a real opportunity to move ahead in this issue. He sat on it. Now, of course, the British have moved ahead and they have seized the leadership. I say more power to them, but as a U.S. citizen, I would much prefer our country do that.

It makes me think of the 8 years we lost in any chance to deal on acid rain during the past administration. So the White House inaction puts the ball over in our court here in the Congress. We will move, Republicans and Democrats alike who want something done.

And maybe the three of you could give us some specific suggestions. Your prepared statements will be put in the record. We will want to get on to the questions and the testimony, so why not go on. Mr. Bissell, then Dr. Miller and then Mr. Blackwelder. And if you could summarize your statements, give us the points you want to especially leave with us.

Mr. BISSELL. Thank you very much, Mr. Chairman. I appreciate the opportunity to be here this morning to talk about global warming. And, as you say, I would appreciate having my statement in full inserted in the record.

There are a few points I would like to make by way of preface which I hope we can keep in mind as we consider this issue and possible policies and programs by AID in this area.

The first focuses on the question of the evidence on which we base our programs. It is not really for AID to split hairs about what is the potential source of and degree of impact of global warming on the developing countries. From our perspective, it is sufficiently self-evident that the potential impact on developing countries is enormous and that, indeed, these countries play a certain role as a source of global warming, as well.

We have heard in the prior panel, quite eloquently, about the potential impact. I thank you for putting together that panel. I think the evidence that has been unearthed there will help us greatly in our work in terms of examining the impact on developing countries.

With regard to sources, most evidence today shows that developing countries contribute a very small amount of total global warming—in the single digits in terms of percentages. Yet, we are concerned about how this might change over the next several decades.

If we are successful in terms of helping developing countries achieve significant economic growth rates these countries can become a significant factor in overall global warming. The potential contribution of developing countries in coming decades requires that we begin now to work with them to reduce emissions of greenhouse gases.

The second point given our desire to become more active in this area, is that we deal in a budget environment that you know all too well, Mr. Chairman. It is one in which there are no free funds to allocate to something one might call a global warming program. In working through the programs of AID, we have identified a number of areas in which we are able to work the issues of global warming into ongoing activities. This is what we call mainstreaming the issue of environment.

As my Administrator, Alan Woods, has said on any number of occasions, the issue of the environment is not addressed in a separate program. It is a foundation upon which we build all of our programs. I would like to enumerate the number of areas in which there is a direct or indirect impact on global warming and the development of solutions to that problem in the work that we do. For instance, we have supported renewable energy and energy conservation projects for many years and continue to make a real contribution to this field.

In the area of environment, with subcategories in the area of forestry, in planning and management, in integrated resources management, we have an impact upon global warming. In the area of agriculture, which, of course, is a very large category of Agency work, we are increasingly integrating sustainability and environmental factors into our project activities.

In the area of family planning, future population levels will have an effect upon global warming. In the area of education, and then last in the areas of employment generation, urban development, and microenterprise, our ability to provide employment off farm, we may reduce pressure upon land use and fragile forested areas.

In each of these areas we believe that we are proactive in addressing potential issues of the environment and global warming in our ongoing programs. And we can point to some success in that regard.

The third point I want to make is that this issue is not simply an American issue. It is one where we find we can make a contribution, but it is one that inevitably will involve all of the donor community in foreign assistance.

In pursuit of this, we have launched a program of enhanced coordination, through the Development Assistance Committee in Paris at the OECD. We are increasing the number of DAC meetings where the problem of global warming is an agenda item this year, to work out with other bilateral donors the relative contributions we can make toward dealing with this problem in developing countries. It is also an issue, I might point out, in terms of donor coordination of research. It is being raised particularly in the consultative group in international agricultural research in trying to focus better the agenda of the various research institutes to take into account the problems of global warming.

The last issue I might raise is simply that, from our perspective, the developing countries are key. Developing countries face very difficult choices. They face, of course, the demands of growth. They want to be able to maintain economic growth rates in their economies that depend not simply upon exotic and new technologies, particularly in the energy area, but also upon obtaining a certain base load of energy supply. That is crucial for growth.

It is also crucial in their desire, as you said to the last panel, Mr. Chairman, in relieving the grinding poverty. And poverty is an issue that easily takes precedence over global problems such as warming, carbon dioxide emissions, and so forth.

Senator LEAHY. I think that bears underlining. It is awfully hard to tell a country they have to make a 10- or 15- or 20-year plan of reforestation when a very large percentage of their people have to eat that day or they are going to starve to death or have to cut what little wood they can find or they are going to freeze to death.

And we add virtually half of the population in my own state every single day in population growth around the world. Those are pressures that are so immediate to the people who are trying to live through them. Literally to determine whether they can live 12 hours more or 24 hours or 36 hours more.

Not because of war or dangers like that, but just by pure hunger or their ability to warm themselves. It creates even further problems. And, of course, that is one of the reasons we are having these hearings. How can we alleviate the immediate problems so that we can work with them to settle the long-range problems?

I did not mean to interrupt you, but I wanted to underscore that one point you were making.

Mr. BISSELL. You make my point very clearly. My last point was simply that with developing countries, we are trying to achieve a long-term partnership. On a global issue like this we cannot afford to have an "us" and "them" mentality. In fact, it is a problem for us all because it is a global problem. And it is one in which developing countries can begin to incorporate a sensitivity, a sense of policy direction, that will sustain them when they reach that stage where they are either a significant source of the problem where, regrettably, the effects of global warming begin to effect their economies and their societies substantially.

PREPARED STATEMENT

So even in those cases where we are dealing with severe poverty, we are introducing this issue as one that becomes part of our overall policy dialog with those governments. Thank you.

[The statement follows:]

STATEMENT OF RICHARD E. BISSELL

Thank you, Mr. Chairman. I appreciate the opportunity to testify on the very important and complicated issue of global warming. The problem of potential climate change and the need to reduce the buildup of greenhouse gases is an issue of growing worldwide concern as witnessed by the introduction of several bills before the Congress, by the number of international meetings on the issue, and the numerous scientific articles appearing on this phenomena.

Developed and developing countries alike clearly must take steps to develop long term strategies to respond to potential climate change. The Agency for International Development is now working with other federal agencies, host governments, and a number of international organizations to understand and address these problems.

The issue of long term climate change is of great concern to the Bush Administration. As you are probably aware, one of the first actions of Secretary of State Baker was to open a meeting of the Intergovernmental Panel on Climate Change last January. At that meeting he raised the following points which, I believe, should guide our efforts:

First, he said that we could not afford to wait until all of the scientific uncertainties have been resolved before we act. Time will not make the problem go away. He suggested that we should focus immediately on prudent steps that are already justified on grounds other than climate change - reducing CFC emissions, greater energy efficiency and reforestation. He said "... solutions will be effective if they transcend the great fault line of our times, the need to reconcile both economic development and a safe environment."

While clearly the threat of climate change is of concern to all countries, the potential effects of global climate change---such as sea level rise, changes in weather and rain fall patterns and the distribution of forests and productive agricultural lands---are likely to have far more serious consequences for people living in the developing world than for us.

Scientific theories suggest that the buildup of greenhouse gases might exacerbate the flooding and drought cycles that characterize many parts of the developing world. Last summer's destructive floods in Bangladesh were a good example of the potential devastation that may become yet more common. The severity of the monsoon floods were increased by the growing destruction of the upland watersheds and higher than usual tides which appear to have slowed the rate at which the flood waters normally flow into the sea. Water covered more than two thirds of the country, leaving approximately 30 million people homeless. Millions of tons of rice were destroyed; roads, power and telephone systems were severely disrupted. Food supplies were also disrupted.

High rates of population growth in developing countries, in some places between 3 and 4% per year, have overburdened traditional systems of agriculture, accelerating deforestation and desertification and have contributed to urban growth at a speed and magnitude not known in developed countries. The migration of people to coastal areas and the development of cities along the coasts raises concerns over the effect of rising water levels and tides.

In some countries, coastal coral reefs serve to protect coastal areas and provide food and habitat for fish and other

marine life. However, these reefs are extremely sensitive to light and temperature changes and could be threatened by global warming.

Drought conditions and the effects of increasingly erratic weather patterns which might accompany climate change threaten development prospects in many areas. The African drought of 1984-86, in combination with poor government policies, put more than 200 million people at risk. Hundreds of thousands died and the future of millions of children is bleak because of extreme malnutrition. The situation would have been even worse had it not been for the massive relief efforts of western governments and private voluntary organizations. U.S. citizens alone contributed an average of more than 60 pounds a person to the African relief effort.

The effects of El Nino contributed to the enormous fire in East Kalimantan (Indonesia) that destroyed several million hectares of virgin tropical forests a few years ago.

It is obvious that developing countries which are already operating at the margin, with barely adequate food, health care, or shelter, would have great difficulty making the adjustments necessary to cope with major changes in agricultural patterns, forest cover, water resources and quality of life. These countries simply do not have the financial, technical, or natural resources to absorb the effects of such changes. Consequently, it is imperative that all countries take steps to mitigate the process of climate change.

Current scientific evidence suggests that four gases are primarily responsible for the greenhouse affect--carbon dioxide

(49%), methane (18%), halocarbons (14%), and nitrous oxide (6%). Carbon dioxide is by far the most abundant of these gases and the single most important greenhouse gas. Fossil fuel combustion and deforestation are the most important man-made sources. The predominant sources of fossil fuel emissions are powerplants, industries, motor vehicles, and residential and commercial establishments. Changes in land use through expansion of agricultural areas, fuelwood demand and commercial logging result in deforestation. This impact is double edged because burning accelerates the rate of CO_2 releases and reduces the capacity of forests to absorb CO_2 . Methane is another important greenhouse gas. Emissions result from the burning of fossil fuels, rice cultivation and animals. Halocarbons, primarily chlorofluorocarbons (CFCs), are a greenhouse gas and also result in depletion of the stratospheric ozone layer. Nitrous oxides result from the use of fertilizers, land clearing biomass burning and fossil fuel combustion.

A.I.D. is currently involved in a number of activities related to global warming. For example, we are funding studies to better understand the current and potential contribution of developing countries to changing levels of greenhouse gases and the effects of potential climate change on selected developing countries. Our energy, forestry, and agricultural programs are helping developing countries to reduce the rate of increase in greenhouse gas concentrations and to cope with the long term effects of climate change. We are also working closely with other bilateral and multilateral assistance agencies to address these problems.

The Oak Ridge National Laboratory and a private consulting firm are preparing twenty-year projections of fossil fuel use

in developing countries, estimating the levels of greenhouse gas emissions from energy use, and attempting to quantify the extent to which improvements in energy efficiency can meet the need for essential new energy supplies. We will also assess other environmental effects associated with increasing energy production and use.

Higher levels of energy use explain the far greater contribution of the developed countries to global climate changes. Statistics on carbon dioxide emissions from fossil fuels show that the U.S. contributes about 25 percent of total emissions which arise primarily from fuels burned in motor vehicles and in the generation of electricity. Western Europe and Japan contribute about 23 percent with the Soviet Union and China contributing another 33 percent.

A.I.D.-assisted countries combined currently contribute less than 10 percent of total fossil fuel emissions. However, when combined with the emissions from the newly-industrializing countries, China, and other non-A.I.D. assisted countries the total contribution of developing countries accounts for about 25 percent of industrial carbon emissions and 40 percent of total greenhouse gas emissions---carbon dioxide, methane, halocarbons, and nitrous oxides.

The economic growth needed so badly by developing countries will require substantial increases in energy use. Even with significant increases in energy efficiency, energy consumption will probably need to increase at rates of 4.5 to 7.2 percent annually if real per capita incomes are to increase at even a minimal level of 2 percent. This would be far above the rate of increase in energy use occurring in the developed world.

Even with increases in fossil energy consumption averaging 6 percent a year, CO₂ emissions from all A.I.D. assisted countries would still be somewhat lower than current emissions from the U.S. I do not mean to minimize the importance of these trends in the developing world nor to suggest that developing countries should not be encouraged to reduce the rate of increase in their use of fossil fuels, but rather to suggest that it is essential for the United States to assume a leadership role on this issue.

ENERGY

A.I.D. has worked closely with many developing countries to promote energy efficiency, to substitute renewable energy resources for fossil fuels and to encourage the use of natural gas and improved power generation technologies, all of which help to reduce rates of increase in CO₂ emissions.

Activities in support of energy conservation and efficiency improvements have been an important part of the agency's energy portfolio since 1980. At that time, A.I.D. recognized that the progress in energy efficiency made by the industrialized countries, in response to the rapid rise in world petroleum prices occurring in the 1970's, could also be made in developing countries. Improvements in energy efficiency offer significant economic benefits, especially important to A.I.D. countries with extremely limited financial resources. Efficiency improvements reduce the need for new energy supply facilities. In addition, such improvements reduce the rate of increase in carbon dioxide emissions as well as those of other gases, such as nitrous oxide, contributing to the greenhouse affect. A.I.D. has provided energy conservation assistance to

over 20 countries. We currently have major in-country programs in Egypt, Morocco, Pakistan and the Philippines and energy efficiency will be the cornerstone of our expanding energy activities in India. A regional program under the auspices of the Association of South East Asian Nations (ASEAN) has provided important assistance to improve the energy efficiency of commercial buildings, an increasingly significant energy consuming sector in those countries with the highest rates of economic growth and urbanization.

Two important activities which complement these technical assistance programs are our policy dialogue activities on energy pricing and our support for innovative approaches to electric utility planning. Energy price reform is clearly essential if energy efficiency improvements are to be sustainable. Most developing countries subsidize energy prices, and these artificially low prices discourage investments in energy efficiency. As part of these policy dialogue efforts, A.I.D. has collaborated with other donors in pressing for tariff increases in Egypt and Pakistan, and, in fact, the government of Egypt has just agreed to raise tariffs.

Another key element of the agency approach to increasing energy efficiency in the power sector is the institution of more comprehensive planning methods. Many of the most important decisions that affect efficiency levels and technology choice are made at the investment planning stage. A.I.D. is investigating ways to promote adoption of a type of utility planning now gaining acceptance in the U.S., usually called least-cost planning, in which "non-conventional" supply options and efficiency improvements on both the supply and demand sides are considered. In 1989, we will complete our

first such exercise, working with the State Electricity Board in Gujarat, India. Later in the year, we will identify and begin work in a second country, and in 1990 and 1991 we intend to expand this activity.

Historically, A.I.D. has supported research and development (R&D) efforts, demonstrations, and full scale dissemination efforts involving a wide variety of renewable energy technologies. While some of these applications proved appropriate and cost-effective others did not. Current efforts focus largely on those technologies which have moved beyond the R&D stage and which can be competitive with conventional energy technologies. For example, projects are underway to support biomass fueled power generation, using common agricultural crops and crop residues such as sugar cane, rice husks and wood wastes. In terms of global warming, this is a neutral factor, since decomposing biomass produces CO₂ as easily as when it is burned. Furthermore, such fuels can reduce demands for additional fossil fuel. Biomass energy systems also give economic value to waste products.

Some people have suggested that A.I.D. should not support fossil energy projects, limiting its energy assistance to conservation and renewable energy technologies. I do not agree.

In those countries where A.I.D. does provide funding for electricity generation, Pakistan and Egypt, new electric power generation technologies are being used that can generate power more efficiently and reduce the environmental impact of power generation. For example, advanced combined cycle gas systems are being put in place that are far more efficient than conventional thermal power plants, resulting in less pollution.

A.I.D.-assisted countries must have increasing supplies of energy if they are to develop. Some of these supplies can come from improvements in energy efficiency and the increasing use of renewable resources---hydro-electricity, biomass, solar, wind and geothermal. However, for the foreseeable future there will still be a need to use fossil fuel resources. A.I.D. can play a critical role, in helping developing countries to use the most environmentally sound technologies and to make use of those energy resources that are the least environmentally harmful. Improvements in coal combustion technologies, in particular atmospheric fluidized bed combustion and integrated gasification combined cycle systems, offer superior technical and environmental performance. In addition, the adoption of cogeneration technologies producing both power and heat, improve the efficiency of energy use and reduce environmental costs.

FORESTRY

A.I.D. also supports a wide variety of efforts designed to reduce the rate of deforestation. These include activities to protect natural forests for sustained use, reforestation of degraded lands, and agroforestry programs to improve agricultural yields. Research activities focused on improved multipurpose tree species hold great promise for strengthening reforestation and agroforestry efforts. During FY 1987, A.I.D. funded 146 forestry projects in 46 developing countries. The total life of project funding for these activities was almost \$600 million.

Forests and other vegetative cover benefit the environment by producing oxygen, fixing carbon, and modifying temperatures. In many tropical countries, and in some

temperate countries as well, deforestation is occurring at an increasing rate in response to the pressures of populations on marginal lands, the clearing of land for agriculture and cattle grazing, increased timber production, and demands for fuelwood. The proportion of increased atmospheric CO₂ attributed to deforestation is now estimated at 25 percent, adding significantly to the levels of CO₂ arising from the burning of fossil fuels.

A.I.D. recognizes forest resources can only be sustained through improved management of existing forests, reforestation, and afforestation. Today, only a very small percentage of the world's tropical forests are managed. The reasons are the lack of political commitment in the face of pressure to convert these lands to farm land and pasture, the misleading perception that economic returns from alternative land uses are higher and limited experience in forest management. A.I.D. is actively supporting a number of programs to develop management strategies for natural forests and to change government policies which encourage slash and burn agriculture and environmentally harmful timber operations, colonization schemes, and cattle ranching in tropical forest areas.

DONOR COORDINATION IN ENERGY AND FORESTRY

A.I.D. has embarked on a number of activities to encourage other bilateral agencies as well as the multilateral development banks and other international agencies to support environmentally sound energy activities and to encourage new forestry activities. For example, we have taken a lead role in developing an agenda for the OECD's Development Assistance Committee to increase donor collaboration and coordination in

addressing environment issues in developing countries. These efforts will focus not only on important local environmental and natural resource issues but also on issues such as responses to potential climate change and ozone depletion. In fact, we have asked DAC members to discuss how they might assist developing countries in implementing the Montreal Protocol on Ozone Depletion at the next DAC meeting on the environment.

During the past year, A.I.D. has organized a collaborative group currently comprising the multilateral development banks (MDBs) and the United Nations Development Program -The Multi-Agency Working Group on Power Sector Innovation. The group expects to develop innovative approaches to meeting the financial and technical needs of developing country utilities, stressing the need to consider environmental effects. One of their first projects is the preparation of a guidebook on sound environmental management in the power sector for use by senior officials in the banks and in developing countries. We are also working with the U.S. Treasury to develop guidelines for use in reviewing energy projects proposed for funding by the multilateral development banks.

A.I.D. has participated actively in the development of the global Tropical Forest Action Plan and is working with other donors and host country governments to assess forest resources and needed management activities in more than 60 countries.

To summarize:

- o A.I.D.-assisted countries contribute only a small fraction of global carbon dioxide emissions from fossil fuels and even with rapid economic growth this will be true

- o promoting energy efficiency is an important component of our efforts in developing countries, but new energy sources will still be needed, both conventional and renewable
- o deforestation contributes to global climate change and A.I.D. in conjunction with other donors and developing countries is supporting efforts to reduce current rates of deforestation and to promote new reforestation
- o donor coordination and collaboration is necessary if we are to help developing countries limit emissions of greenhouse gases and cope with the effects of potential climate change. It is essential, however, that the U.S. take a lead role in showing other developed and developing countries that it can make the transition to reduced levels of fossil energy use and reductions in emissions of all greenhouse gases.

STATEMENT OF ROBERT H. MILLER, HEAD, DEPARTMENT OF SOIL SCIENCES, NORTH CAROLINA STATE UNIVERSITY

Senator LEAHY. Dr. Miller?

Dr. MILLER. Thank you, Mr. Chairman. Some of the things that I am going to talk about will address the deforestation reduction issue and some of the things that can be done in agricultural development in the tropics that will marketedly reduce the impact of deforestation.

I am going to talk first about policy and related issues, then about AID itself. And then I will, if I have time, talk about the technical aspects. If not, these comments are in the report which I am certain all of you have in your hands.

I think the question to be asked is what should the U.S. Government do about deforestation we have already heard something about it. I would just briefly say that this is not something we can do ourselves. It is something that has to involve other countries, various agencies, it is just too massive a problem for any one country or agency. At an international conference, active participation by the United States must be in a leadership role.

Within the United States, I think there are some actions and responses that seem most appropriate. Again these are outlined in greater detail in the material I provided. I think it is important

that AID assign a very high priority to funding alternatives for slash and burn agriculture as the top agriculture priority in the U.S. AID agricultural account. This is the 103 account.

What I am really concerned about, and it is my understanding that this is true, perhaps Mr. Bissell can respond, there is really not a specific mandate in the Foreign Assistance Act for addressing environmental resource conservation issues in which deforestation reduction is part. So although a priority you do not have a mandate for action, which makes it easier to do agricultural production kinds of things with U.S. AID than it does to be involved in resource conservation issues.

In addition, enhanced funding commitments without a strong focus in internal reorganization of U.S. AID may not be as effective as it could be. I think that it is not just AID that has this mission. I think other Federal agencies such as the USDA and the EPA must also be integrated into AID programs, activities and in the development of ideas. I do not see that degree of participation at this point.

I think it is also interesting——

Senator LEAHY. Keep taking notes, Mr. Bissell, because we will give you a chance to respond after we get through.

Mr. BISSELL. Yes.

Dr. MILLER. I am also very interested in the fact that there is talk about reorganization and separating the more humanitarian aspects of AID from military aid. My colleague and I would certainly say that reorganization seems to be a very good idea, but that it may not be necessary to begin addressing the issue of reforestation reduction.

I understand that within AID there are some work groups addressing natural resource conservation and deforestation that are starting to meet together. I think that is commendable. But I do not think we have the degree of integration, at least in my perception, that will really be effective in resolving these important problems.

I have also mentioned in here that as a scientist and as an administrator at a major university, I am concerned that AID has yet to utilize what I consider to be the best reservoir of technical information available anywhere, that in the U.S. universities. Title XII programs have done some very admirable things. Yet, there is more that can be done.

There are some opportunities in university involvement that should be taken advantage of now. The formation of a new CRSP under the title XII of the Foreign Assistance Act which deals with problems of natural resource maintenance and deforestation would be an important part of AID's enhanced commitment to the U.S. universities. In return, AID would benefit from the technology which is very real and already present in our major universities. This is a great resource.

I have already talked about interdisciplinary linkages of U.S. agencies. I think the CGIAR system of international centers of agriculture must also have a renewed focus, basically a first-time focus, on technologies for reforestation, resource management, and sustainable agriculture. There are some related agencies, like

IFDC, IBSRAM, ICRAF, TSBF that should be brought into this dialog and future program activities through the CGIAR system.

I think the strategy should be less in crop germ plasm research in these agriculture institutes and more programming in the environmentally related areas.

There is something else that I think stands in the way of AID's active participation in deforestation issues, and that is that many of the main deforesting countries are AID graduates. And we find, through our programs, that it is very difficult for us to work with AID graduate countries. I suspect AID itself, also finds it very difficult, given the current constraints. I think there has to be something done to remedy this situation so that you can work more easily to resolve deforestation problems in these important countries.

U.S. AID and other people and agencies must be able to work in Brazil, Columbia, Mexico, India, and Thailand which are graduate countries of AID. I think that this is a very serious problem at the present time.

Although not an American agency, the World Bank is certainly an important participant in these issues. World Bank activities must be focused more on human resources and research operations than on bricks and mortars. I think it is very important for World Bank projects to consider their impact on deforestation and on environmental issues much more than they have in the past. This really means a major change in direction. I think the U.S. Government and U.S. AID have a very big role to play in assisting the World Bank in changing their focus.

I am also concerned that the United States does not believe that farmers involved in slash and burn agriculture do so because they want to. They do it because they have few opportunities in their major cities because of a lack of development and intense population pressure.

So we must be concerned about AID's involvement in population and family planning activities and in doing something to resolve the problems of international debt. These problems do not allow, do not provide a way for countries to help themselves and help their own people and reduce the pressure on those valuable forest resources.

So, again, Third World farmers are not there slashing and burning for the fun of it. They are there trying to make a living. Many live in poverty, and their opportunities are all too few.

The last point I want to make is that it will be necessary for U.S. policy and initiatives to reduce deforestation to be sensitive to the needs and the aspirations of other countries. I think we have to make a very definite policy to do something about fossil fuel consumption in this country before we can expect any Third World country to participate in any way in a deforestation reduction program. We have to set an example.

PREPARED STATEMENT

This has been said in different ways here this morning. I think it has to be said again. It is a very significant point. There are other things which could be said but for brevity I will close my remarks at this point.

[The statement follows:]

STATEMENT OF ROBERT H. MILLER

I appreciate the opportunity of appearing before this joint meeting of the Foreign Operations Sub-committee of the Senate Committee on Appropriations and the Senate Agricultural Committee. This testimony was prepared jointly by Dr. Pedro Sanchez and myself. Many of you already may know Dr. Sanchez because of his previous testimony to other congressional committees and his involvement in deforestation issues at the national level. This week he is in Yurimaguas, Peru working with the faculty and graduate students of the Soil Science Department's Tropical Soils Program in the Amazon basin of Peru.

This testimony is designed to provide input on possible solutions (both technical and of a policy nature) to reduce deforestation and its impact on "global warming." I am certain that previous testimony has provided adequate background concerning the causes of the greenhouse effect and the models which support the global warming scenarios. I will not take time to repeat the statistics concerning the percent contribution of deforestation to the total problem of global warming. Those data are probably very familiar to all of you at this time. Just let it be said that deforestation is a large, but certainly not the largest, contributor, of greenhouse gases but it is one which must be addressed effectively as we wrestle with a global solution to the very serious problem of global warming.

First, I will address changes in U. S. agricultural assistance policy which will impact on deforestation reduction and second provide a technical strategy for a sustainable agriculture in third world countries which provides alternative to "slash and burn."

Proposed changes in agricultural assistance policy

The question to be asked, and hopefully answered, is "What should the US Government do to support a worldwide deforestation reduction effort?"

1. Global warming and deforestation reduction can in no way be carried out by unilateral activities of the USA! The U. S., because of its preeminent position in the world, must be prepared to provide the leadership which will develop policies and actions of a worldwide coalition of sovereign governments, agencies, scientists, and the interested private sector. This list should include USAID, World Bank, regional development banks, FAO, UNEP, UNDP; bilateral donors such as Japan, EEC countries, Canada, New

Zealand and Australia; international environmental groups, and even multinational corporations.

2. Within the U. S. the following actions and responses seem appropriate:

- a. Assign sustainable alternatives to slash and burn agriculture as the top agricultural priority in the USAID agricultural account (103). It may be necessary to reallocate funds from lower priority areas to deforestation reduction. Food and Agriculture (103) accounts currently focus predominantly on agricultural production and alleviation of hunger. This focus is certainly commendable but these efforts and environmental goals are not necessarily compatible. There currently is not a specific mandate in the Foreign Assistance Act for addressing environmental-resource conservation issues.
- b. Enhanced funding commitments without a strong focus and internal organization in USAID may not be effective. It will be necessary to establish interdisciplinary work groups within AID and with other governmental agencies i.e., that integrate USDA, EPA, all relevant agriculture, forestry, and resource conservation technology staff with policy staff. Whether this is done within the existing structure of USAID or another organization separated from the military is not that important. Personally we see some great advantages in a reorganization which would separate more humanitarian types of AID activities, i.e., agriculture, forestry, family planning, resource conservation from the policies and politics of military aid. It is my understanding that attempts at establishing interdisciplinary working groups within USAID on the topic of global warming have begun. This is commendable, but more needs to be done so that the necessary policy and action decisions have a strong consensus and support for implementation.
- c. Speaking as a scientist and as an administrator at a major university the following statement should not be surprising, but I assure you it is truthful and important to this discussion. It should be recognized that the comparative advantage of the U. S. is in its technical expertise in agriculture, forestry, natural resources, conservation, and policy. Most of this expertise resides as a largely untapped reserve on the faculty of U. S. universities. Technical expertise is

not, perhaps shouldn't be, USAID's strength. Thus any broad interdisciplinary national effort for deforestation reduction depends on improved USAID-university relationships which involve long term financial commitments to universities. The formation of a new CRSP under Title XII of the Foreign Assistance Act which deals with problems of natural resource maintenance and deforestation would be an important part of AID's enhanced commitment to U. S. universities. In return AID would benefit from the technology which resides in these institutions.

- c. Other types of interdisciplinary, interagency organization of a global scope must also be addressed. For example the U. S. should play a leadership role in the creation of an International Resource Management Organization within the CGIAR system, merging existing related international efforts such as IFDC, IBSRAM, ICRAF and TSBF. Additionally, it may be necessary to give higher priority to resource management of the marginal ecosystems (humid tropics, steeplands) than the current crop-germplasm focused international centers (IRRI, IITA, CIAT, CIP, etc.).
- d. USAID must recognize that the main deforesting countries are AID graduates including Brazil, Columbia, Mexico, India, Thailand, etc. New mechanisms must be established so that we can collaborate with them in the same way we collaborate with AID support countries with deforestation problems. These countries include Indonesia, Peru, Bolivia, Zaire, Panama, and Costa Rica.
- e. The U. S. must provide leadership in focusing World Bank activities and projects more on human resources and research operation than on "bricks and mortar." The World Bank should consider direct support of technical assistance for key country programs and organizations attempting to address deforestation reduction issues rather than the highly visible big ticket projects.
- f. Individual farmers involved in cutting tropical rainforests do not do so because they are environmentally irresponsible, rather, do so out of necessity to survive. Population pressures are in part responsible for migration to rainforests as well as the lack of economic opportunity

(jobs) in major cities of the third world. Thus USAID must enhance their effort in providing assistance in family planning and the U. S. government must find ways to reduce the international debt which seriously hinders internal development in many countries, but especially those which have the greatest areas of uncut forests.

- g. It will be necessary for U. S. policy and initiatives to reduce deforestation to be sensitive to the needs and aspirations of other countries. We should recognize that although deforestation is important as a cause of global warming it is not as important a cause as our internal consumption and burning of fossil fuels. We must demonstrate that we are willing to develop policies and action to prevent our contributions to the greenhouse effect while working with other countries cooperatively in implementing policies and agricultural strategies which reduce deforestation. No quick fixes can be envisioned. We are dealing with an initiative which is as important and as global as was that of the Green Revolution. The results, however, will not be as dramatic and certainly more gradual. "Get tough" intrusive policies are unlikely to be effective.

Technology to Support Agricultural Development and Reduce Deforestation

My colleague, Dr. Sanchez, has addressed this issue many times, most recently in Testimony to the Subcommittee on Natural Resources, Agricultural Research and the Environment of the House Committee on Science, Space and Technology. Portions of this testimony which provide an appropriate technological approach to sustained agricultural development with markedly reduced deforestation follows.

The key is an integrated approach consisting of a) development and application of sustainable management technologies for tropical soils, b) appropriate government policies that provide incentives against further deforestation, and c) effective, economically sound rainforest conservation methods.

People do not cut tropical rainforests because they like to; they clear them out of sheer necessity to grow more food. Deforestation, therefore, can be reduced by the widespread adoption of sustainable management practices that permit the use of cleared land on a continued basis. Sustainable management

options for acid soils of the humid tropics have been developed at Yurimaguas, Peru, and elsewhere to fit different landscape positions, soils and levels of socioeconomic infrastructure development (Figure 2).

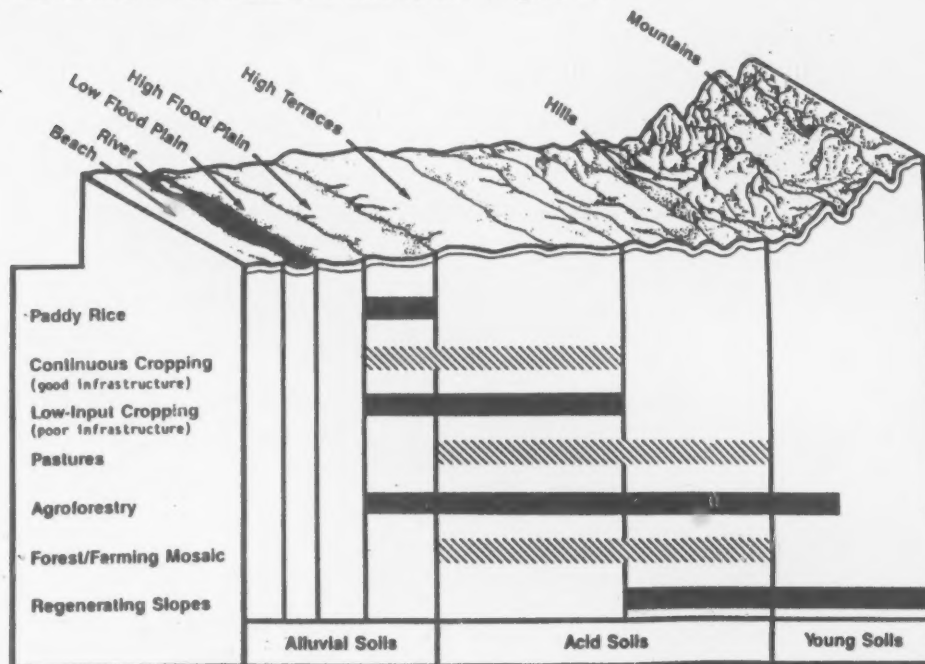


Figure 2. Some soil management options for humid tropical landscapes dominated by Oxisols and Ultisols (3).

Most of the options are based on low-input systems which serve as transition technology to agroforestry systems, legume-based pastures and continuous crop rotations. In spite of the continuing need for both strategic and applied research, there is no question that the technological basis for sustainable management options for acid soils of the humid tropics is available now.

Land Clearing that does not damage the soil

All the options are based on slash and burn, using axes, machetes and chain-saws as opposed to mechanized bulldozer clearing. We found that the slash and burn system is better because the burn provides a liming fertilizing effect of the ash, does not disturb the topsoil while conventional bulldozer clearing often compacts the soil and removes valuable topsoil (8). When our results were transmitted to our colleagues in Brazil and Indonesia, policies to discourage bulldozer clearing were instituted. We also found little difference in fertilizer content of the ash after burning primary or second forests (9) giving a further impetus to clear secondary forests, instead of primary ones.

Flooded Rice in Alluvial Soils

One obvious option is to first use intensively the best soils available in the area: the alluvial soils of most humid tropical rivers which are naturally fertile but are not subject to annual flooding. Traditional paddy rice production technology developed by Southeast Asian farmers, coupled with high yielding varieties suitable to local tastes and appropriate agronomic practices has been successfully adopted by settlers and local people in the Amazon of Peru. With low-cost supplemental irrigation, farmers harvest two crops per year averaging 5.5 tons/ha or 11 tons of grain per hectare per year. This is practiced in over 50,000 hectares of the Peruvian Amazon under the leadership of Peru's National Rice Program (10). There is great internal demand for rice, a guaranteed price and sufficient infrastructure to deliver this basic food to the rest of the country. However the product is not of sufficient quality for export markets.

Low-Input Cropping for Acid Soils

In the vast majority of the humid tropics the soils are acid and with low fertility and farmers slash and burn forests to produce one or two crops of rice or corn each averaging about 1 ton/ha of grain before leaving the land in a forest fallow. Then they cut additional forest the following year. A low-input cropping system was developed in Yurimaguas, Peru to serve as a transition technology between shifting and continuous cultivation (4).

Its main features are:

- Slash and burn secondary forest fallows.
- Use of acid-tolerant crops.
- Capture nutrients in the ash.
- Maximum nutrient recycling.
- Zero tillage (only a planting stick is used).
- Managed fallow to control weeds.

Acid-tolerant varieties of upland rice and cowpeas (black-eyed peas) were found to grow very well at a very acid soil pH (4.5) without liming. Seven crops of a rice-cowpea rotation were harvested in a three year period with high grain yields. By carefully returning all crop residues (rice straw and cowpea stover) to the field we were able to recycle 54% of the nitrogen, 70% of the magnesium, 89% of the potassium, 95% of the calcium but only 38% of the phosphorus accumulated by the crop. In addition nitrogen fixation by the legume cowpea must have contributed to the nitrogen balance. The problem is phosphorus since this element is concentrated in the grain and is thus removed from the field by harvest. Although no fertilizers, or lime were added to the field, what farmers remove in their crop harvest must eventually be returned back to the soil in sustainable agricultural systems. If not we are mining the soil of its nutrients.

Crop yields declined with time due to phosphorus deficiency and increasing weed pressure which could not be economically controlled by low cost herbicides. The system was then put into a managed tropical kudzu

fallow, which rapidly covered the ground, smothered the weeds and totally protected the soil from erosion. After one year, the kudzu was slashed and burned and a second cropping cycle started. Unlike the species of kudzu that grows in Southeastern United States (*Pueraria lobata*), tropical kudzu (*Pueraria phaseoloides*) does not develop storage roots and is thus simple to eradicate by slash and burn. This low-input system was found to be highly profitable averaging \$1144 per hectare per year or 121 percent return over total costs, which were largely hand labor by small farmers (4).

This low-input system, therefore, is a transitional technology in both agronomic and economic terms. After three years, the field is devoid of felled logs and most of the remaining tree stumps are sufficiently decomposed to be easily destroyed. The land-clearing process is thus complete, providing several options to the farmers, such as the following: to put the land into a managed fallow and then start a second cropping cycle; to plow, lime, fertilize, and rotate crops intensively; to establish pastures; and to establish agroforestry systems.

Managed fallows

Traditional shifting cultivation involves a secondary forest fallow period of 4 to 20 years, to replenish soil nutrient availability and control weeds. Farmer experience around Yurimaguas indicates that a minimum desired age of fallow is about 12 years, but population pressures effectively reduce this period to an average of 4 years. Slashing and burning young forest fallows result in faster grass weed invasion than would occur in older fallows because the weed seed pool declines with age. Considering the limited likelihood of long secondary fallow periods in humid tropical areas in developing countries, the need for an improved fallow is apparent. Research is currently underway to test various leguminous species as managed fallows, in addition to kudzu. We still do not know whether a second or third cropping cycle is sustainable. Research is underway.

Continuous Crop Rotations

Another option is for the low-input system to serve as a three-year transitional period to intensive, fertilizer-based, continuous cropping systems for areas that have developed a sufficient road, credit, and market infrastructure to make this possibility attractive. The field is ready for mechanized tillage, provided that slopes are suitable, because most of the felled vegetation has decomposed. This system has proven to be sustainable with about 40 crops grown continuously in 17 years at Yurimaguas (11). In order to decrease weed infestation it is advisable to use a kudzu fallow before shifting to intensive crop production.

Legume-based pastures

Pastures for beef and milk production are an attractive option in the Latin American humid tropics and one in particular need of improved technology because of widespread pasture degradation. The low-input system can also serve as a precursor to establishing improved, acid-tolerant pastures, beginning with the clearing of secondary forests. Income-

generating food crops can be grown, and the pasture species may be planted either vegetatively or by seed under a rice canopy. Several combinations of persistent, acid-tolerant grasses and legumes have produced high and sustained live-weight gains of the cattle in Yurimaguas for eight years (12). Phosphorus and potassium fertilizers are applied annually or every two years. The kudzu fallow itself could be used as a pasture in rotation with grass-based pastures. Degraded pastures have been regenerated using similar techniques. Similar work has proven successful in the Amazon of Brazil (13).

Agroforestry

The low-input cropping system is a good way of providing cash income and ground cover during the establishment phase of tree plantations. The decision, however, has to be made early in order to plant the tree crops shortly after clearing and burning the secondary forest. Unless liming is contemplated, the choice of tree crops should be limited to acid-tolerant ones. Examples of acid-tolerant crops for industrial purposes are rubber, oil palm, and guarana (Paulinia cupana); for food production, peach palm (Bractis gasipaes); for alley cropping, Inga edulis. Woody species known to be sensitive to soil acidity, such as Theobroma cacao and Leucaena leucocephala, should be avoided.

The low-input system has been used successfully in Yurimaguas for the establishment of peach palm and multipurpose tree production systems that include fast-growing (Inga edulis) and slow-growing (Cedrelinga cataeniformis) forestry species (14).

DEFORESTATION REDUCTION

For every hectare put into these sustainable technologies by farmers, five to ten hectares per year of tropical rainforests will be saved from the shifting cultivator's ax, because of their higher productivity. Estimates at Yurimaguas for the various management options are as follows. These estimates will vary with climate and soils.

1 hectare in sustainable management options	Equals: hectares saved from deforestation annually
Flooded rice	11.0
Low-input cropping (transitional)	4.6
Continuous cropping	8.8
Legume-based pastures	10.5
Agroforestry systems	not determined

Such technologies are equally applicable to secondary forest fallows, where clearing emits less carbon dioxide emission to the atmosphere than primary forests because of smaller tree biomass. Also much of genetic diversity has been already lost in secondary forests. The use of secondary forest fallows is therefore, an excellent alternative to primary forest clearing. Many of the degraded or unproductive pastures or croplands resulting from poor management practices can also be reclaimed using some of these available technologies.

Such technologies, however, are useless without effective government policies that encourage, support and regulate them. Likewise, well conceived policies will fail without sustainable technologies. Therefore the hope lies on a joint policy-technology approach: The Deforestation Reduction Initiative (3).

The present situation is analogous to when the world technical assistance community launched the Green Revolution in the late 1960's. At that time sustainable technologies for high-yielding rice and wheat production were sufficiently developed to be tested at a large scale. Key government officials were convinced of their importance by leading scientists, and instituted the necessary policies to make massive farmer adoption possible in India, Pakistan, The Philippines and other countries. The Green Revolution became a worldwide success during the next twenty years and the goal of arresting worldwide famine was definitely achieved. Unlike the Green Revolution, however, the impact of the Deforestation Reduction Initiative will be gradual and less spectacular. This is because we are focusing on marginal ecosystems, and more complex technological and policy problems.

In conclusion, Mr. Chairman, a worldwide Deforestation Reduction Initiative will help directly the livelihood of both Third World countries and the developed countries as well. Sustainable agricultural options for the humid tropics are a necessary, but not sufficient conditions to stop tropical deforestation (15). Coupled with appropriate, conservation-oriented government policies the following objectives can be achieved at the same time.

- Increase food and fiber production by farmers now practicing shifting cultivation.
- Reverse the pattern of degradation of many of the lands already cleared of tropical rainforest.
- Preserve much of the remaining tropical rainforests with their rich genetic diversity.
- Alleviate emission of greenhouse gases by as much as 20 percent.

Thank you.

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Senator LEAHY. Trust me, I will read them. I think you have made a good statement. I am glad you have raised the issues you have. I sometimes wish that we had been having this same committee hearing 10 years ago.

Sir, you are next.

STATEMENT OF BRENT BLACKWELDER, VICE PRESIDENT, ENVIRONMENTAL PROTECTION INSTITUTE, FRIENDS OF THE EARTH AND THE OCEANIC SOCIETY

Mr. BLACKWELDER. Thank you, Mr. Chairman for the opportunity to testify. My testimony is in three parts. I would like to address the Multilateral Development Banks, mention the International Monetary Fund and then finally, describe AID and present to you a little energy demonstration as well.

I think the point with respect to the Multilateral Development Banks is that the efforts of the appropriations committees during the past decade have been significant and these need to be reiterated in the upcoming appropriations if we are going to continue to make progress there. The Multilateral Development Banks could go a long way to make the countries around the world energy efficient, if they chose to take that role seriously. And that is the key handle we have on global warming.

But there is a problem. We heard earlier this morning the question of whether developing countries really want this. What is their attitude toward global warming? Well just recently, Minister Umana from Costa Rica asked the World Bank for help on energy efficiency programs in Central America and got a cold shoulder from the World Bank.

Clearly, these countries are asking for help. They are looking for us to provide this kind of assistance at the time of global warming. If we do not come through with this kind of foreign assistance, both bilaterally and multilaterally, then they are going to be disappointed. I think it is quite a different perspective than we were hearing earlier.

With respect to the International Monetary Fund, here is an agency to which I hope some explicit direction would be given during the appropriations process and in other forums because the International Monetary Fund has not focused on the implication of its lending, its structural adjustment programs can dramatically affect developing countries' natural resource base. Its prescriptions are really for the short run: Export more, import less and cut back on government spending. Well this means pull out those natural resources as fast as you can to get the hard cash.

The IMF does not look at these environmental impacts. And anything the committees can do to try to get the IMF to take a longer-range perspective on natural resource management would be beneficial. And in particular, any way the debt problem facing developing countries is settled—and that is a \$1 trillion plus problem—has got to include a vision for sustainable natural resource management. If that is missing, those economies will collapse in the not-too-distant future. You cannot keep going at the rate in which they have been going recently.

Let me come back then, finally, to address AID's position and problems. I think if you reflect on the AID statement, you have to

ask yourself the question: Is this the dynamic leadership we need to face perhaps as crucial a problem as the planet has ever faced? I have not heard any goals laid down, any real enthusiasm and ambition set forward in this AID statement. We need superb leadership if we are going to do anything about this. We cannot have AID actually coming up with a budget request that reduces its energy lending by a million dollars.

We have to transform that energy lending into efficiency improvements because these are the most cost-effective investment that any country can make, developed or developing. They get you more energy per dollar spent than any investment. And they can be done quickly. You do not have long-lead construction times. They are not capital intensive so they do not drain the hard-pressed developing countries' economies for capital.

They are socially and environmentally beneficial. And I will illustrate one of those investments in a minute. It seems to me AID or some other agency ought immediately to be gathering the data that we heard was needed to describe how much forest loss is occurring on a country-by-country basis. This is simple data that could be gathered, it is my understanding at about \$15,000 per country. So we would really know what is the forest loss from 1 year to the next.

Also AID ought to be restructuring its agriculture programs and its forestry programs to make projects such as we have described in this report, "Bankrolling Successes" which we put out last year for the annual meeting of the World Bank or projects described in this report by the Rodale Institute "Experiences in Regenerative Agriculture" or those examples of successful forestry and reforestation by the Smithsonian Institution report entitled "Saving Our Tropical Forests." There is no shortage of examples of sustainable forestry and agriculture projects, but these tend to be more the exception and not the rule. The question is, with strong committee directives, we could move AID and multilateral assistance in that direction.

If you could just plug this extension cord in over there, I would just like to conclude by showing you what I have here. This is a \$30 billion suitcase, Mr. Chairman.

Senator LEAHY. 30 which?

Mr. BLACKWELDER. \$30 billion. By that I mean that if consumers in the United States—

Senator LEAHY. I thought you had brought a new cold fusion experiment here for us. [Laughter.]

Mr. BLACKWELDER. If consumers in the United States use these bulbs wherever you now use a screw-in incandescent bulb, we would save ourselves as consumers about \$30 billion per year. Roughly one quarter of the electricity used in the United States is for light bulbs. I mean, if we replace those in the ceiling here in the committee room with these screw-in bulbs, maybe \$500, \$750 would be saved in electricity bills over the life of the bulbs.

These are equally applicable to developing countries as they are to industrial countries.

And, in fact, some of these efficiency devices are made in developing countries. It is not as my friend here said, exotic new technologies that we would impose. In fact, this kind of device makes sense. It can be put in place immediately. But how many of these

projects do we see AID or the World Bank implementing to make immediate drops in the electricity consumption in developing countries?

Here is an outdoor use bulb and I will show you if you unscrew this you do not—just have those flickering cold tones, but they come in a wide array of tones. Now you could set this on a place for a——

Senator LEAHY. Why don't we use these?

Mr. BLACKWELDER. It is a good question. My only answer is that environmentalists are not Madison Avenue marketing types. But there is a good piece of——

Senator LEAHY. Are they that much more expensive?

Mr. BLACKWELDER. Yes, they are 10 times more expensive, but they save you probably—a bulb like this, the Phillips Co. claims will save you to \$30 to \$40 on your electricity bills. They last 13 times as long and they use only about 10 to 20 percent of the energy of an incandescent. So, immediately, in the United States you could reduce the electricity use by 15 to 20 percent if you were able to get these into every spot.

What I am saying for lights goes for efficient motors, gears and so forth, for appliances; all of these are possible.

PREPARED STATEMENT

You have got different colors that you can put on these as well. You have got reflectors that can increase your illumination by 25 percent. These are not sophisticated technologies that are beyond the means of developing countries; they are applicable wherever you would like to go.

So I just conclude with that.

[The statement follows:]

STATEMENT OF BRET BLACKWELDER

I am Brent Blackwelder, Vice-President of the Environmental Policy Institute, Friends of the Earth and the Oceanic Society. This statement was prepared by members of our International Department, including James Barnes (Senior Attorney), Chip Fay (Director of the Asian Development Bank Monitoring Project) and Bonnie Souza (Director of the Central American Project). Earlier this year the Environmental Policy Institute, Friends of the Earth and the Oceanic Society merged to form a new global advocacy organization with 33 international affiliates.

We are pleased for the opportunity to present this testimony and wish at the outset to commend the Subcommittee for its outstanding work to address urgent global environmental problems.

We hope that the Subcommittee will reiterate some of the very important concerns about energy, global warming, and transportation which it expressed in last year's appropriation bill. Some progress on reforms is being made by the multilateral development banks (MDBs), but the ongoing expression of Congressional interest is essential for achieving lasting solutions.

We also want to introduce to the Committee a booklet on sustainable development that we co-authored last year, entitled "Bankrolling Successes: A Portfolio of Sustainable Projects." We ask that it be incorporated into the record as an exhibit to our formal statement. In this context, we challenge the World Bank and the other MDBs to put the principles of truly sustainable development to work. "Sustainable Development" has become a phrase used widely by many institutions and organizations, which sets out a goal. It can, however, mean many different things.

This booklet sets out an intellectual framework for sustainability that is based on experience at the grass roots level in Latin America, Africa and Asia. The projects featured are, for the most part, sponsored by non-governmental organizations. They are not mega-projects, but rather are appropriate to the needs of the local people and draw on those people. The time frame of "success" is critical: one must look at the record over a period of decades rather than a rate of return figure derived from only a few years' experience.

I. ENVIRONMENTAL ISSUES AT THE ASIAN DEVELOPMENT BANK

A number of the Bank's Governors have been raising the profile of environmental issues in the Asian Development Bank (ADB), particularly in the context of what has come to be known as "sustainable development". At last year's meeting in Manila, 31 Governors mentioned in their presentations the need for the Bank to play a greater role in solving natural resource management and general environmental problems.

Since then the Bank commissioned a "Blue Ribbon Panel" led by Saburo Okita, former Foreign Minister of Japan, to make recommendations on future directions for the ADB. Its report listed environmental protection as one of the three recommended new priorities. Just in advance of the annual meeting the President of the ADB has announced that the former Environmental Unit will now be the Environmental Division. Presumably this will enhance its influence within the institution.

Environmental groups that are concerned about the environmental impacts of projects funded by the MDBs have greeted the new high-level support at the ADB with enthusiasm. For the

past few years, the ADB has enjoyed a growing reputation among environmentalists for its policies on environmental review of projects. It has indicated a willingness to fund environmentally beneficial projects. The ADB's reputation, however, has been based more on published policies and procedures than any detailed analysis of what is happening on the ground. EPI established a field office in Manila last year in order to work more closely both with ADB staff and with NGOs in the region.

While praising the performance of the Division, EPI and other environmental groups have urged ADB officials to make a significant commitment to increasing the staffing levels in the Environmental Division. Particularly necessary are additional trained personnel in environmental monitoring and the design of environmentally focused projects.

Despite the high level of verbal support from the Bank's Governors and management for expanding environmental initiatives, it is not yet clear how committed the institution is to making the necessary adjustments in resources to ensure that an increase in environmental beneficial lending takes place. Presently, only three professionals are assigned to the Environment Division. While those employees are demonstrating notable competence, it is apparent that current staffing levels are insufficient to do what the Bank says it is doing, to say nothing of the promises made for the future to address critical environmental and natural resource management issues in the Asia/Pacific region.

In the words of the Okita Blue Ribbon Panel Report, these staff levels are "not substantial". Furthermore, the Report states that "It is probable that staffing ratios [in general] are now falling below levels required to sustain effective operational capability in some areas."

The ADB is showing the ability to present and develop important environmental initiatives. Programs are underway to implement minimum quality criteria for ecologically sensitive areas, and to apply geographic information systems for the management of environmental and natural resources. An important regional study on economic policies for sustainable development, "Implementation of the Brundtland Commission's Recommendations", is another positive example.

These initiatives demonstrate that the ADB is capable of providing significant leadership in addressing global and regional environmental issues. What remains uncertain is the degree to which the Bank is willing to translate the increased interest in environmental considerations into a greater commitment to taking steps to expand the Bank's environmental activities. Thus far, only new one professional position has been committed to the Environmental division.

The Okita report concludes that, "There remains considerable scope for improving the environmental impact of Bank lending, both indirectly through better design of normal projects and directly through projects addressing specific environmental problems, such as tropical forest loss or desertification." To accomplish this will require a prompt increase in the Environment Division.

At least eight professionals with corresponding increases in support staff are needed within the next two years in order to carry out the verbal commitment to expanding the operational capability in environmentally related areas of the Bank's work. While such an expansion is hoped for by many, inside and outside the Bank, it is unlikely to happen without greater support from key member countries, particularly Japan and the US. Awareness

that environmental quality and proper natural resource management are central to sound development planning is increasing at all levels within the ADB. The time has arrived for that awareness to be transformed into a commitment to play a leadership role among the multilateral development institutions.

Three substantive areas that deserve close attention by the Governors and Executive Directors are forestry, energy and building up national institutions with responsibility for managing natural resources and protecting the environment.

A. Forestry

The ADB has been pursuing its own approach to tropical forest issues, primarily through the development of Master Plans in individual countries.

In the countries where Master Plans have been developed there has been little or no NGO involvement and the policy changes necessary for forestry to be sustainable are not being seriously addressed. Natural forestry management must be put on a sustainable basis. According to the latest studies of the International Institute for Environment and Development, less than 1% of tropical forests worldwide are being managed sustainably.

Moreover, it is apparent from the record of the Master Plans prepared so far that there is very little coordination with the multilateral and bilateral aid agencies involved with the Tropical Forestry Action Plan, which aims to promote donor coordination of various policy and management reforms in tropical countries. Similarly, there has been regrettably little intersection with the important policy work of the International Tropical Timber Organization. The ITTO shortly will be debating its new Action Plan, at a meeting of parties in the Ivory Coast May 16-24. The ADB should be represented there, with instructions to play a constructive role in integrating the forest work of the ITTO and the ADB.

Another area where the ADB could demonstrate leadership on tropical forest issues is in promoting the development of "extractive reserves". This concept has been proven in Brazil in recent years. It allows economic utilization of the forest on a truly sustainable basis, while leaving the forest intact. Among the economic resources that can be obtained are rubber, nuts, rattan, medicinal substances, and natural dyes. Extractive reserves protect the homes of forest dwellers, both peasants and indigenous peoples.

B. Energy

EPI and its colleagues in the international environmental community are urging the ADB to change the priorities to support greatly increased investments in efficiency and conservation. These are the best investments in both economic and environmental terms. Many studies show that investments in energy efficiency and conservation on the demand side are four to six times more cost effective than investments in new hydropower, coal or oil-fired power plants. For each country there will be a different mix of conservation and efficiency investments, but all of these can be put in place quickly and will pay for themselves in a relatively short time, thus saving precious capital. In urban areas investments in more efficient motors, street and commercial lighting, mass transportation and refrigerators may make the most sense, while in rural areas more efficient motors to run irrigation pumps would save large quantities of energy.

Almost all energy lending by the multilateral development banks has gone into large capital intensive projects. Cost-effective loans for energy conservation are, in general, not being made. This situation is all the more disturbing in light of the severe debt problems facing many countries and the mounting concern about warming of our atmosphere.

C. National Institutions for Managing Natural Resources

In order for the ADB to play its proper role in assisting developing nations with the institutions needed to manage natural resources and protect the environment, a ten year program of grants, investments and training for every borrowing country in the region would be desirable. If nations lack these capabilities, the likelihood of other environmental policy objectives being achieved is dubious.

II. IMF Initiatives

We note that there is a pending request of the International Monetary Fund for an increase - perhaps a doubling - of member country quotas. This issue was addressed at an IMF Interim Committee meeting here on April 3-4, and will come up again later this year. It is our belief that the Administration should condition its support for this increase on the IMF's willingness to consider the impacts of its economic policy prescriptions on social and environmental sectors of national economies. Until that happens, we are opposed to US support for a capital increase.

During the past five years the Congress has enacted legislation relating to the multilateral development banks and the IMF, designed to achieve reforms in those institutions' policies, procedures, staffing patterns and program implementation. The IMF has not acknowledged that its policies and economic prescriptions can adversely affect the social and environmental sectors throughout the Third World, and hence has taken no discernible steps on the path of reform.

Although the IMF does not finance specific projects, its prescriptions for dealing with balance-of-payments problems can have a significantly negative impact on natural resource exploitation and on the need for social stability. The IMF's stabilization and structural adjustment programs, such as policies focused on increased exports and the curtailment of domestic consumption, are in some instances eroding the very base upon which future economic growth and social well-being depend.

It is a widely shared perception in the public interest community that IMF actions have had negative impacts on sustainable management of natural resources, environmental protection, health care, education and nutrition. Often these negative impacts have fallen hardest on children, women and the poor. Our analysis indicates that, unlike the World Bank, the IMF does not conduct studies of possible environmental and social consequences of its actions. In part this is a result of the absence of personnel on the IMF staff in the areas of natural resources, poverty, women in development, and other related subjects, as well as the lack of consultation with affected people.

Among the questions that the Congress should raise are those laid out in a letter to Secretary Brady from Senators Kerry, Lugar, Boschwitz, Pell and Sanford, dated February 21:

** Does the IMF conduct studies of the projected environmental and social consequences of its macroeconomic and microeconomic policy prescriptions?

* Are there any qualified natural resource economists on the IMF staff, a requirement which is necessary in order to evaluate the environmental impacts of stabilization and structural adjustment packages for individual countries, as well as the effect of such policies on the natural resource base of a particular country over the long term.

* Are there development economists on the IMF staff who are trained to understand the practical realities of development, particularly the linkages between short-term exploitation of natural resources and longer-term impacts on the society as a whole?

* Are there poverty experts on the IMF staff, which would be required in order to study and predict the impacts of IMF policy prescriptions on the poorest segments of society, particularly women and children?

* Does the IMF have an independent evaluation unit to review whether the goals of its policy prescriptions have been realized, what lessons were learned, and what should be done differently in the future in order to avoid or minimize adverse social and environmental impacts?

* Does the IMF have a policy unit to advise the Managing Director on Inter-regional issues such as environmentally sustainable development and declining health and nutrition levels?

* Does the IMF make appropriate use of its relationships with the World Bank in taking into account these questions and then participating in actions in order to meet the vital needs of the poor majority in developing nations."

The question of an increase in financial resources for the IMF is extremely important, particularly in view of its role in overseeing efforts by members to deal with their debts. We are not opposed in principle to an increase, but we urge that it be part of an agreement by the IMF to institute certain changes in its policy prescriptions in light of their environmental and social impacts.

It would seem to be desirable for the IMF to work closely with the World Bank in evaluating whether its macroeconomic policy prescriptions adversely affect natural resources management and other social sectors. Likewise, it would be wise to create an independent evaluation unit would systematically review whether the goals of the IMF's economic prescriptions have been achieved. The IMF should, as a matter of sound policy modify its future actions so as to avoid undermining natural resources management and other social sectors that constitute the base for future sustainable growth. Similarly, it would seem to be useful for the IMF to create a policy unit to advise its Managing Director on sustainable development, health, nutrition and poverty issues in the context of structural adjustment.

There is no doubt that the IMF plays a key role in many developing nations. If it can begin to integrate social and environmental considerations into its adjustment policies, that would help achieve development that is really sustainable. We note that an important World Bank staff report presented to the Development Committee in the spring of 1987 calls for the environmental effects of macroeconomic conditions and policies promoted by all multilateral development institutions, including the IMF, to be taken fully into account. If this is not done, the long-term goals of the World Bank could increasingly be undermined by the IMF's adjustment programs.

We urge that US officials in the Departments of State and Treasury be instructed to consult widely with other IMF members as the best way to promote these types of reforms at the IMF, and that there be report to Congress in six months. During that period the US should make no commitments regarding the proposed capital increase.

III. Central America

Citizens, policy makers and the press in the United States debate the social causes and consequences of conflict in Central America, but seldom address the profound environmental crisis now affecting the region. The U.S. has spent billions of dollars in Central America since 1981 to pursue its policies in the region. It is our contention that this economic and military assistance has contributed to severe environmental degradation in Central America.

A. Economic Assistance

U.S. development policies, which greatly favor the export sector, have supported IMF-like structural changes, the devotion of the best land and resources in Central America to cash crops for export, and the consequent migration of the region's majority --the subsistence sector-- onto marginal lands, into the rainforest, or into the cities in search of employment. We believe that such an export-oriented model is a very dangerous one and is a prime effort to decrease self reliance. We are vigorously opposed to leading Central America down such a path with tragic environmental consequences. Highly skewed land ownership and land use practices supported by the U.S. are largely responsible for the displacement of hundreds of thousands of people, which has created vast numbers of internally-displaced refugees and placed serious pressures on the region's natural resources.

A good example is El Salvador, whose environment is the most degraded in Latin America. In El Salvador, less than 2% of the population controls nearly all the fertile land and 60% of the entire national territory. The National Parks Service reports that more than 95% of El Salvador's original tropical deciduous forests is gone and today less than 7% of the country is forested. USAID has reported that 494,000 acres of land currently in subsistence food production (roughly 10% of total area in El Salvador) need alternative, more ecologically-sound uses. Land held idle or in pasture by large growers should go into sustainable production for basic food crops to meet human needs, allowing marginal lands to be restored. Massive reforestation efforts are warranted, not only in El Salvador, but in all Central American countries, and USAID should devote the funds necessary to replant these forests.

In the Choluteca/Valle region in southwestern Honduras, deforestation, primarily due to cotton production and cattle ranching which began in the 1950s, has rendered this part of

Honduras a desert, resulting in severe erosion, summer droughts and winter floods. Due to desertification of this region, many thousands of Hondurans have been forced to colonize forested areas in other parts of the country, such as in Olancho.

Mangrove destruction in the Gulf of Fonseca is a growing concern and serious environmental issue that must be addressed in U.S. development policy. Our staff recently visited the region and reported that mangrove destruction is rapidly increasing as a result of increased commercial shrimp production, the production of non-traditional exports such as melons, salt processing, and tanneries. In the Gulf of Fonseca, 5000 people in twelve communities have formed a new organization, The Committee for the Defense of the Flora and Fauna of the Gulf of Fonseca (CODDEFFAGOLF), to defend the natural resources in the Gulf. These small fishermen, agriculturists and aquaculturists say that mangrove destruction is eliminating their way of life, that it is destroying the social structure for the people of southwestern Honduras who have lived off the mangroves for many generations. Production of cotton and non-traditional crops such as melons require excessive use of pesticides, which are poisoning the water, mollusks in the Gulf, and the bees necessary for pollination. Although alternative solar methods are being used to process salt, many processors are burning wood from the mangroves for this purpose.

B. Security Assistance

U. S. military spending in Central America has exacerbated the region's environmental in through a variety of ways. In El Salvador, the war's effects on the environment are deepening the country's ecological crisis and fueling the poverty behind the conflict. Wide areas of Morazan and northern Chalatenango provinces -- areas of strongest guerrilla support and the worst fighting -- have become virtual wastelands, with crops destroyed, forests burned and the landscape scarred with bomb craters. Counterinsurgency tactics that include defoliation, bombings and burning of forests have affected El Salvador, Guatemala, and Nicaragua. The contra war has been responsible for the kidnap or murder of over 75 environmental and natural resource employees in Nicaragua, the burning of reforestation projects, and continues to contribute to the increased deforestation rate in Honduras, especially along the Nicaraguan border. The contras are reported to be equipped with chainsaws which they are using without regulation to fell trees and clear land. According to the Miami Herald, they are receiving chainsaw safety training paid for by U.S.AID. U.S. military spending in Honduras has greatly increased the deforestation rate, due to nearly continuous U.S. military operations, National Guard exercises and U.S. Army construction projects that have left the country criss-crossed with military roads and scarred with over ten major military bases and airstrips.

War in Central America has displaced hundreds of thousands, creating refugee populations in every Central American country which, in turn, places enormous additional pressure on the region's fragile tropical ecosystems. War has also forced Central American governments to divert monies away from environmental restoration and protection and into the military, resulting in a serious decline in environmental resource agencies and their budgets. Instead of addressing the severely-degraded condition of Central America's environment and the great need for building environmental institutions, the United States has devoted much of its bi-lateral assistance to military uses. For example, in 1986, the U.S. spent 18 times as much on military aid to El Salvador and Honduras as it did on environmental protection for the entire Caribbean region.

C. Alternative Policy Options

It is our perception that funding used to "promote security and stability" is leading directly to serious environmental damage and social upheaval that will guarantee continued social unrest and instability. We wish to suggest an innovative proposal which might help reverse the rapid decline in tropical forests and other natural resources on which ultimately the lives of all Central Americans depend. We believe international parks and nature reserves can help promote peace and environmentally sound development in Central America by requiring a cooperative effort between neighboring nations. These zones could become centers of internationally significant research and economic development through rational resource management.

The idea of creating international reserves in the region emerged at the First Central American Meeting on the Conservation of Natural and Cultural Resources in San Jose, Costa Rica, in 1974. In the years following this meeting, a number of Central American countries began to dedicate some of their scarce economic resources to protecting shared natural resources and promoting sustainable development in border regions. La Amistad International Park on the Costa Rica-Panama border is a result of these efforts.

When the five Central American Presidents signed the Esquipulas II peace accords in August, 1987, they inspired hope among Central American environmentalists as well as concerned scientists and citizens around the world that the military activities ravaging the region's environment would come to an end.

The Arias peace plan breathed new life into the movement to create international parks in the region. On February 5, 1988, Costa Rica's Minister of Natural Resources, Alvaro Umana, and the Director of IRENA (Nicaragua's environmental agency), Julio Castillo, signed a letter of intent to create an international biosphere reserve on their border.

Costa Rica's and Nicaragua's proposed International System of Protected Areas for Peace would conserve 2,500 square kilometers of pristine tropical rainforest and wetlands in its core area alone. This proposal is an integrated development project which aims to protect precious natural resources on both sides of the border while promoting economic development in surrounding zones, thus raising the standard of living of people in the zone and contributing to peace in the region.

Cessation of military aid and a relative winding down of the contra war against Nicaragua has created the space for the formation of SI-A-PAZ. Already, the Swedish, Dutch and Norwegian governments have financially supported SI-A-PAZ and have committed funds to this project once it becomes bi-national. A convention center for SI-A-PAZ has been built with Swedish money on the Nicaraguan side of the proposed system. Local people on the Nicaraguan side have been included in the planning stages thus far for SI-A-PAZ, are helping create and are very supportive of the plans. Our staff that recently visited the region and met with government officials and NGO staff in both Nicaragua and Costa Rica. Both countries remain interested in moving forward toward the creation of a bi-national system.

U.S. assistance could help turn the tide in U.S. relations with Central America from one of war and environmental destruction to one of peace with justice and sustainable development. SI-A-PAZ should be funded for two three-year phases. The budget for the first phase would be: \$80,000 for year one; \$160,000 for year two; and \$320,000 for year three, and

to increase exponentially for each of the remaining three years. The first year, the money would be used for preparation of initial studies, for meetings of interested government and non-government technical people. Inventories would be prepared and some preliminary mapping of the areas could be developed. The first year would be used to better define the zones of management. There could also be seminars with leading international figures to discuss what SI-A-PAZ could mean and to discuss other international parks. Much of the money would be used to train people. Many highly qualified people, including specialists on eco-tourism, would be brought in to talk to both sides and to have conferences. Many additional ideas for development of SI-A-PAZ have been detailed by involved parties on both sides of the border.

Parks that span borders could play a crucial role in easing tensions on the isthmus. We urge the Committee to give endorsement to this concept and in particular to fund the proposed biosphere reserve on the Costa Rica-Nicaragua border. We believe that SI-A-PAZ has the potential to serve as a global model for environmentally-sustainable tropical rainforest development.

IV. Debt

We urge that the IMF and World Bank establish a special facility or window with the goal of assisting in large scale debt-for-nature swaps and other creative approaches to debt reduction. The new facility could be able to carry on the following types of activities:

1. To act as broker or facilitator between institutions in developed countries who purchase discounted debt and appropriate foundations and other local non-governmental organizations in the borrower countries. It is our understanding that there are many institutions willing to purchase discounted debt and exchange it for long-term local currency instruments that can be used for conservation, natural resources management, environmental protection, energy efficiency improvements and other investments in social sectors.
2. To guarantee local currency "debt reduction" instruments such as bonds, that are issued by a developing country government in exchange for discounted debt purchased by other entities, as part of an agreement for needed investments in environmental and social sectors.
3. To buy up foreign debt at the prevailing market discounts, which could be exchanged by the Bank facility or the borrowing government for local currency instruments which be used for investments in natural resources management, environmental protection, and other social sectors.

In these ways the World Bank and the IMF could play a most constructive role in helping to alleviate the debt crisis and at the same time lay a foundation for truly sustainable development in the future. Although these proposals would not totally solve the debt problems of developing countries, they could be a substantial component and would have immediately beneficial implications by reducing both principal and interest payments. All that is necessary is the will to act.

We urge the Congress to direct our Executive Directors to the World Bank and IMF to prepare a concrete plan of action to

implement these initiatives. An immediate dialogue needs to be opened with officials of those institutions and other Executive Directors.

V. Staff levels at the World Bank

It is apparent that the regional environmental units which have been established are too small to do the work required. Given the number and scope of projects and other Bank activities in each region, and bearing in mind the long lives of many projects, a staff level of four to six professionals is manifestly inadequate. We suggest that each regional unit be immediately increased in size to at least sixteen professionals, and that the goal for the next year be to have these units operating with perhaps 25 professionals.

VI. Access To Information

The problems which we have brought to this committee in earlier years about access to the basic documents about project have not been resolved. Information which logically should be available to the public about projects which involve support from countries around the world is treated as if it were a highly classified military secret.

We believe that this deliberate policy disguises some serious shortcomings of projects. Two examples of recent problems will show that this past problem has not been remedied. First, we cannot obtain the review of the Three Gorges Dam in China prepared by the World Bank last year. Second, we have not been able to get from the World Bank the appendices to the Narmada Project in India which lay out the basic economic assumptions for this multi-billion dollar investment. Thus it appears that whenever there is a project about which citizens from all over the world have a particular interest, the information is kept secret.

VII. Cost Benefit Analysis and the Present Economic Models

The experience of the last three years suggests that not much has changed at the World Bank regarding the critical tools used to evaluate projects and investments. One good example is the experience with the Narmada Dam scheme in India. The Staff Appraisal Report and Cost-Benefit analysis carried out in 1985 are fundamentally flawed, and are leading the Bank down the path to another debacle of probably epic proportion.

Attached to this statement is our letter of March 8, 1988 to Mr. Alisbah, head of the India country desk at the World Bank, which outlines the many egregious deficiencies in that Cost-Benefit analysis. We are awaiting a response from the World Bank. There are good indications that senior staff agree with us that the Appraisal Report and Cost-Benefit analysis is badly flawed.

We hope that Congress will require the Department of Treasury to carry out a more focused effort with the Bank to ensure that such debacles do not continue to happen.

VIII. The Philippines

EPI/FOE has an office in Manila to monitor the activities of the Asian Development Bank and to work with Philippine environmental and rural development organizations on important natural resource issues. It is vitally important that the \$200

million requested for aid to the Philippines be devoted primarily to environmental restoration for the reasons which we sketch out below.

The well-being of the Philippine people is inextricably bound up with the health of the ecosystems which sustain the various islands. These ecosystems have, for the most part, been severely degraded by massive, uncontrolled logging followed by enormous erosion and sedimentation of rivers, extensive industrial and pesticide pollution, and ruination of fisheries.

Once magnificent forests covered about half the Philippines (16.6 million hectares). Now less than one million hectares of ancient forest remains. Over one million hectares of virgin forest were cut during the last decade. The result of such extensive clearing, which has not been followed by reforestation, is wholesale watershed destruction. Rivers flood at record levels and then almost dry up without the forests providing the base flow in the dry season. The Agno River, for example, has silted up so much that in some areas it is higher than the surrounding rice fields. In the Cagayan River 2.5 million hectares are eroded. Studies by AID and U.N. organizations have highlighted the alteration of rainfall, the ruination of reservoirs, and the dramatically increased flooding. The downstream sedimentation is so severe that it damages bays and estuaries and destroys coral reefs.

Of about 10 million hectares of land now under cultivation, only 5.6 million are classified as suitable for crop production and only 2.8 are flat lowland suitable for several crops a year. About 60% of the land in the Philippines has a slope greater than 18%, so soil erosion is a major problem. Erosion has eaten away at productivity. Pollution has further hurt agricultural production. For example, mine tailings carried downstream by the Agno River have clogged irrigation canals and have reduced crop yields by 20-50%. The rapidly increasing population is putting further pressure on the fragile land base.

Fisheries have been decimated by mining discharges, manufacturing wastes, sewage, agricultural chemicals, and oil barging operations. Coral reefs comprise about 30% of the shallow marine waters of the Philippines and contribute perhaps one quarter of the fish catch. The Marine Sciences Center at the University of the Philippines reported in 1981 that one third of the coral reef locations it monitored had less than 25% of their living coral cover left. Only 5.5% of the locations had 75% of their coral cover remaining.

We believe that a substantial portion of the \$200 million should go into the completion and initial implementation of an environmental master plan to restore the degraded forests, fisheries, rivers, bays and watersheds of the islands. In particular, the following steps make sense:

- 1) ensure that U.S. bases are operated in an environmentally sensitive manner. This means that the bases should be efficient in the use of energy and water, that they should be carrying out good land stewardship and forestry, that they should properly be treating wastes and avoiding the creation of toxic dumps.
- 2) forgive the debt owed on the ill-conceived nuclear power plant financed by the Export-Import Bank in the 1970's.
- 3) provide the essential support for reforestation and watershed restoration, while at the same time working to end the illegal logging and special interest timber concessions.

- 4) reorient fisheries money away from high-technology fishing which causes overfishing and put it into municipal fishermen who practice sustainable fishing.
- 5) support citizen groups carrying out environmental restoration projects.
- 6) support family planning programs.

We are providing the Committee with a copy of **Resources, Population, and the Philippines' Future**, a World Resources Institute publication written by Gareth Porter with Delfin Ganapin. This report provides far more detail on the environmental destruction of the Philippines than is possible to present in this testimony. Simply put, this is an essential document for those who desire to understand the present plight of the Philippines in terms of natural resources and the environment. We urge that our embassy in the Philippines be directed to be fully cooperative in assisting Philippine officials and NGOs in preparing an urgent action plan for restoring the Philippines environment.

IX. United Nations Environment Program

We urge the Committee to provide a sharply increased budget for UNEP of between \$20 and \$25 million, in view of the outstanding work which UNEP has done on global climate change and the Montreal Protocol. It is not wise to continue this organization at a funding level equivalent to what the U.S. provided over a decade ago. The problems and challenges are so much greater that a quantum leap in funding is essential to help provide solutions.

With additional resources UNEP could, for example, take the lead in convening an international intergovernmental conference to secure a global Convention on Land-based Sources of Marine Pollution, and carry out a similar effort to negotiate a Convention on Conservation of Biological Diversity.

X. NOAA and the Intergovernmental Oceanographic Commission

The Intergovernmental Oceanographic Commission (IOC) is the prime mechanism for international oceanographic forums on a governmental level. NOAA is the United States representative, but in the past has received funding at only about a \$500,000 level. There is an urgent need for funding at about \$3 million to enable meaningful participation.

The funds for IOC, which is located under UNESCO, are controlled by the State Department. The importance of U.S. work in this area may not fully be appreciated. The role of the oceans in global climate is in need of major research and monitoring. Now is the time for significant funding increases.

Senator LEAHY. Mr. Bissell, I am hoping you are not taking all the comments about AID personally. You know the high regard I have for you. So I wonder if you might like to respond to some of the things either Dr. Miller or Mr. Blackwelder said?

Mr. BISSELL. I think they had some very interesting suggestions. Let me try to respond briefly and informally to some of these ideas, because we are always looking for a better idea.

Senator LEAHY. Like a better light bulb.

Mr. BISSELL. Right.

DEVELOPING COUNTRY INVOLVEMENT

Going back to Dr. Miller's points, first. He raised some very useful ideas here and in his statement for the record, which I, fortunately, had a chance to look at this morning.

The suggestion that this issue must be responded to by many different countries and organizations is, as I mentioned in my own opening remarks, a very valuable one. One area that he highlighted, which I think needs a little more emphasis, is the international environmental groups. The international environmental groups, it seems to me, play a crucial role, not only in terms of working directly with AID, but in cloning their own type of organizations in developing countries.

This will always be our issue, as opposed to a developing country issue, until there are indigenous PVO's and other nongovernmental organizations that carry this same message within their own societies. At that point it will no longer be an alien issue, it will be one that they will want to incorporate into their own political processes.

We can see this occurring even in those countries that people consider the most sensitive, such as Brazil, where the creation of environmental groups is beginning to have a measurable impact; not an overwhelming impact, but a measurable impact upon the policy process. And I think Dr. Miller's point there is a very useful one. It is one where AID, working with United States PVO's, can begin to help them to develop their like-minded groups in developing countries.

AID AGRICULTURE ACCOUNT

Second is the issue of the priorities in the AID agricultural account. It strikes me that the slash and burn issue is not a universal issue. Indeed, many of those countries where it is most crucial are either graduates, or, as he said, ones in which we may not have a significant presence. But I take the point and I think it is one that will, over time, have an emerging importance in the agriculture account.

Agriculture programs are not the kinds of programs that turn around from year to year. They have to have a sustainable impact and a presence in terms of life of project and program. I think Dr. Miller's input will be useful, and we will attempt to work out a growing priority for his suggestion within the agriculture account.

As he said, there is not a specific mandate in the FAA today. However, it is interesting that in our discussions with the House Foreign Affairs Committee in the course of this year, sustainable, environmentally sensitive, development as one of the four objectives of the Foreign Assistance Act is one idea that has been suggested and that we endorse. And I think there is a mechanism in that authorization legislation to build it in in a way that should provide a meeting ground for all of us interested in this area.

INTERDISCIPLINARY COORDINATION

A third point which he made, concerned increasing interdisciplinary work groups, both within AID and with other Federal agen-

cies. This is happening. Again, this is a slow process. Bureaucracies do not change their habits overnight, but as this issue is a focus of increasing concern, we will work with each other on a more efficient and, hopefully, effective basis.

The relationship between AID and U.S. universities on this issue has been a source of concern for us for the last 12 months. The Administrator took this issue up, in fact, with BIFAD in the course of the last year. He urged BIFAD, as our major interlocutor with the title XII universities, to take on environmental issues and global warming as a new and significant focus among several issues. He stated BIFAD and the universities should not remain so closely wedded to what has been their traditional focus in their work with AID.

So this is an objective that we would endorse. And we hope that we can use the BIFAD mechanism to draw universities into greater work in this area. Whether or not this calls for a new CRSP, or not, is hard for me to judge. I am not an expert in that area. Whether that is the right mechanism can be worked out in consultations between AID and BIFAD.

U.S. ROLE IN CGIAR

Another issue that Dr. Miller raised was the increased leadership role for the United States in the CGIAR system. This of course, involves other donors, and we work together through the World Bank-chaired consultative group. Last year, we took a leadership role within the CGIAR to set aside \$2 million for alley cropping, involving new programs within those centers in order to try to address some of these land use and deforestation issues.

AID STRATEGY TOWARD ADVANCED DEVELOPING COUNTRIES

Dr. Miller also raised a question about working with graduate countries, such as Brazil, Colombia, Mexico, and so forth, and again, we have been focusing on that. In those countries where we have an AID representative, as we do in Mexico and Brazil, for instance, a central mandate of those representatives—they are one-man shops really—has been the environment. Those programs will inevitably remain very small. They do not involve a significant policy dialog with the government, because they are, as I say, simply one-person offices.

We are putting together, within the agency, a new strategy toward advanced developing countries, as we call them. I would hope that the environment would be a major theme of that new strategy. It is one we will have to consult with you about, both in terms of expanding AID's roles in these countries, as well as for finding funding to support those programs. But we agree with that emphasis.

PROGRAM STRUCTURE FOR GLOBAL WARMING ACTIVITIES

Senator LEAHY. If we wanted to get more focus in AID on global warming, if we wanted to give you more resources for it, for example, what is the best way? Do we put more money into existing programs that might be aimed at global warming problems? Or would

it be better if AID set up a whole new program; if AID pulled together in one place all its global warming activities, and we channeled resources into that new structure?

You talk about these one-person shops. Their ability to do anything is really in constant relationship to how much they reflect what appears to be the national goals of our country. If it does not appear that the U.S. Government is interested in global warming—as was certainly the appearance we gave to the rest of the world in not going to the meeting in Geneva—then the impression we give to the rest of the world is that we do not care, yet that leading environmentalist Margaret Thatcher, does.

These are the kind of impressions that we are giving in this Nation. So even if we do channel funds, unless we have got a statement from the top, of course, it does not do much good. But what should we do: put more into what we have or a whole new program?

Mr. BISSELL. Your point about U.S. leadership is very valid. Certainly the position of AID representatives is strengthened considerably where U.S. leadership exists. But those representatives also work very closely with the U.S. private voluntary organizations. Insofar as the U.S. private sector is also committed to this, then their position is strengthened.

However, I would argue against having a separate program on global warming. And that is because I do not like to see an issue, in effect, marginalized—that is, set off in its own exclusive pasture—when what is really at stake is how we conduct agriculture policies, what kind of content there is in education, what kind of employment programs we have, what effect energy and environmental programs that are already part of the on-going program have. All of our programs need to be more sensitive to global warming issues.

This can be done, for instance, by adding elements to on-going policy dialog. Macroeconomic issues should increasingly take into account environmental issues. To create a separate program and to treat it as a separate issue creates a political fence around it, which is really inappropriate. This should be part of all the development calculations in a developing country. I think, over time, that will happen. But again, it has to be a host country program—one in which we can provide assistance in a measured way to help them to understand what, I think we are already realizing in the United States—is a very important issue.

AID EARLY WARNING SYSTEM—MDB PROJECTS

Senator LEAHY. You had said in your testimony that AID is trying to improve the environmental performance of the multilateral development banks [MDB's], something that I think all members of this committee would agree on. And you said that AID has a list of MDB projects with potential environmental problems. Approximately how many projects are currently on that list, and what gets done with the list?

Mr. BISSELL. Over the last 2 years it has been a fascinating process to work with the MDB's in identifying those projects that had the greatest potential for environmental damage.

What we have done is draw up a list of what we considered the most problematic projects, on the basis of an early-warning system, taking advantage of early access to project design in the World Bank and the regional banks. Frequently involved are very large capital projects, such as hydroelectric installations or very large integrated rural development schemes.

When we identify a project design that has the potential for either catastrophic or severe environmental damage, we bring the potential problems to the attention of bank staff. And we hopefully have an opportunity to talk to them early in the project design stage to discuss issues that they may have inadvertently overlooked. The staff are themselves in a process of dialog with the government to which they plan to lend the money for those projects.

So we can work with the bank staff, and the staff can hopefully work with the Government, who is to receive the loan, to amend the projects. We find that, in most cases, they either amend the project or defer the loan.

In a few cases we have reached an impasse; generally not between us and the bank staff, but rather between the bank and the Government to which a loan has been informally committed. But overall, the effect has been very healthy.

Senator LEAHY. Do the Government and bank staff pay attention to your list? Do they pay attention to these things?

Mr. BISSELL. Yes; they do. They pay a great deal of attention, in part, because the list is not only sent to them, it is sent to the Congress and released to the press at the time that we develop it every 6 months. As a result, a good deal of publicity has been drawn to those lists in a way that in prior years had never been done.

We are gratified with the results so far. And frankly, it leaves the United States in a far greater position to have an effect. Before when we did not have that kind of early consultative mechanism with bank staff, it came to an issue at the time of a vote. And to put a no vote down on a project at an executive board meeting of the bank is a nice statement, but it has little effect in terms of the project design. And our interest is, of course, avoiding damage to the environment.

ALTERNATIVES TO SLASH AND BURN AGRICULTURE

Senator LEAHY. Thank you.

Dr. Miller, you suggested that AID make sustainable alternatives to slash and burn agriculture as a top priority in its agriculture, forestry and nutrition account. In a lot of these countries there is a major focus just on food production to alleviate hunger—something referred to earlier. It is hard to talk about a 10-year plan or a 5-year plan, and in some instances I suppose, it is hard to talk about a 10-day plan because of the immediacy of hunger.

How do you change that focus? I mean, are we in an absolute Hobson's choice here?

Dr. MILLER. To answer this question let me mention some things that we have been very much involved in in the Amazon Basin; which indicate that there are some alternatives to the normal way agriculture is done. For every individual farmer that would adopt a particular alternative, based on what we consider very good re-

search, we should be able to reduce a very large proportionate amount of deforestation. These approaches are covered by Dr. Sanchez' comments in the materials that are provided.

These ideas are there to be used. If adopted they will provide both the necessary food as well as being more environmentally responsible. So you are alleviating hunger at the same time that you have a very positive impact on improving the environment and reducing deforestation. To me, that is a win-win kind of combination.

As always, having technology adopted within any country, including our own, is very difficult. So when you look at this technology you have to work for widespread adoption; and that is where you have to work with the particular sovereign governments and their particular responsible groups and agencies so that they are committed to implementation.

I think implementation is the key; not that the technology is not available for these areas.

AID POPULATION PROGRAMS

Senator LEAHY. What about population control. How do you rate AID in that regard?

Dr. MILLER. I would say during the last 8 or 9 years their support has been very poor, relative to what I think it had been or should be or could be.

AID AND ENERGY PROBLEMS IN DEVELOPING COUNTRIES

Senator LEAHY. Dr. Blackwelder, you criticized the administration's response to global warming as inadequate. And you suggested a major role for AID to assist developing countries cope with their energy problems. You have also said that the multilateral development banks are not doing enough in this area.

I ask this question as sort of a follow-up to one I asked a few minutes ago. You say that the MDB's are part of the problem. Can you tell me more about how AID and the MDB's could help developing countries become more energy self-sufficient? Is that really within their capacity?

Dr. BLACKWELDER. I think it, indeed, is. One thing that I think the committee and the Congress could do would be to start laying out goals and objectives in the energy area. Because, despite previous directives to pay more attention to energy efficiency, the bulk of the money, 99 percent of the money that the multilaterals spend, is still for the same old things: big coal, oil refineries, large hydrodams, transmission lines, and so forth.

So if you set up goals, say, laying down percentages that we would expect the multilateral banks to be moving to rapidly over the next couple of years, we have the strongest of all economic arguments to offer these bankers. After all, they get a much better rate of return, four to six times better, than any of these other energy investments.

Now the question is though, can they do it? Are they in the position to do it? The answer, I think, is yes, because these bulbs cost more initially, so you need some financier for developing countries. People will not buy them, or industries will not necessarily put

them in because they do not look to the long-term payback, which is there, but any banker should be looking to that.

The banks could provide the finance; AID could provide the finance, then you have the supplier. Many companies manufacture these, here and abroad. OK? And then you look for the distributor within the country. It might be the local utility, the local municipality for street lights, a local industry group to put in the modern motors or gears, and so on.

So that model will work, but it takes some leadership and it takes determination.

Senator LEAHY. Thank you.

Anyone of the three of you want to add anything else, here is your chance.

Mr. Bissell, do you?

Mr. BISSELL. I am fine.

Senator LEAHY. Dr. Blackwelder?

Dr. BLACKWELDER. Well, I always have a lot of things to add. But I will just mention one very innovative concept that is coming out of Brazil is the idea of keeping the forest as a forest and extracting commercially valuable products. It is called extractive reserves.

And there is some evidence now being produced by study at the Yale School of Forestry that these extractive reserves produce yields that can exceed anything you would get for timber production or for cattle ranching. Whereas timber production and cattle ranching may give you \$1,500 to \$2,000 per acre, some experiments done by Hempstead suggest anywhere from \$10,000 to \$50,000 yields from growing certain kinds of fruits.

And this would supplement the earlier studies showing how effective rubber tapping and brazil nut gathering are for sustainable use of these forests. And we have hundreds of thousands of people in the Amazon depending upon the forest as a forest for their livelihood. So we should keep that in mind and try. I think AID and the multilaterals could promote this concept of extractive reserves.

Senator LEAHY. And retain the forests at the same time?

Dr. BLACKWELDER. You retain the forest as a forest, but it requires looking at the full range of commercially valuable products that can be extracted on a sustainable, nondepletive basis; and those are there.

ADDITIONAL COMMITTEE QUESTIONS

Senator LEAHY. There may be some additional questions from various Senators which we will submit for your response.

[The following questions were not asked at the hearing, but were submitted to the witnesses for response subsequent to the hearing:]

QUESTIONS SUBMITTED BY SENATOR ROBERT W. KASTEN

MEASURING DEVELOPING COUNTRIES' RESOURCE BASE

SENATOR KASTEN: Many of the economies of developing nations are based on resource exploitation. However, our current measures of GNP do not measure the health of the resource base. In fact, the resources of many of these nations are collapsing. In effect, they are eating their own seed corn.

What is A.I.D. now doing to review its economic modeling to more accurately measure what I will call "National Sustainable Product?" By that I mean real growth in jobs and adding value, not just fishing out an estuary or cutting down a forest.

MR. BISSELL: A.I.D. is working to help developing nations to achieve sustainable broad-based growth. As you point out, growth cannot be sustained if a nation's resource base is not managed efficiently from a long term point of view. In designing its projects and programs, A.I.D. tries to apply growth models that incorporate all the relevant elements in a nation's economy and politics.

As you have also pointed out, current measures of GNP do not measure changes in a nation's resource base. This standard GNP measure is adequate for many purposes. But A.I.D.'s concern for the big picture of all the elements affected growth compels us to consider household activities and natural resource changes not directly measured by GNP. We also consider the political policies and practices that determine much in the incentive system that influences the uses made of the resource base. We are, therefore, applying models that, so far as possible, incorporate economic and political elements that are of important relevance even though not incorporated in GNP measures.

We welcome the many efforts now under way -- and are funding some of them -- to identify output and productivity measures that will incorporate changes in the resource base. At present, we are some distance from establishing measures that will command general acceptance; but in the meantime, we are paying careful attention to those other elements.

In addition to our efforts to improve output and productivity measures, we are working to improve the government policies and practices shaping the incentives guiding resource users. Our policy dialogue -- from ongoing talks with host officials to conditioned program assistance -- is directed at correcting both market failures and government failures affecting natural resource uses. That is to say, where markets fail to induce efficient natural resource utilization, we seek appropriate compensatory government policies; and where, as is frequently the case, governments actually subsidize environmental degradation or tax or otherwise discourage environmental protection, we seek corrective reforms.

Finally, we seek to ensure that each of our projects meets reasonable environmental criteria. Each A.I.D. project is accompanied by an environmental impact assessment, and if the conclusion is that a project could not be completed without serious negative environmental effects, then A.I.D. will not support it.

A.I.D.'s PREPARED STATEMENT

SENATOR KASTEN: Did OMB make any changes in the content of your statement?

MR. BISSELL: No, OMB made no substantive changes to my statement.

DEBT FOR NATURE EXCHANGES

SENATOR KASTEN: What are the most important changes we can make in law to encourage A.I.D. to be aggressive in carrying out solid Debt for Nature exchanges?

MR. BISSELL: The most important change we can make to encourage A.I.D. to be aggressive in carrying out solid debt for nature exchanges is to amend current statutory provisions that prohibit grantees from retaining interest earned on local currency received from debt for nature and other debt/development exchanges. Many governments, such as Costa Rica, cannot provide ready cash in exchange for their debt. Because of tight current budgets, many of which are constrained by IMF ceilings, cooperating governments prefer to offer bonds (usually with maintenance of value provisions) which pay interest and thereby provide a PVO a long-run source of revenue. While many PVOs prefer such an arrangement, current law requires that the interest be returned to the U.S. Treasury. This requirement precludes many governments from participating in the Debt for Development Initiative, and I would support removing this provision of the law for Debt for Nature and other debt for development exchanges utilizing A.I.D. funds.

Senator Kasten: What cultural problems are we likely to face if we promote the kinds of alternative agriculture you are advocating?

Answer: Adoption of new technology is difficult in any area as you well know, and we feel that the problem is technology transfer and adoption rather than specific cultural problems. We do not anticipate any cultural problems because the recommended management schemes involve main crops familiar to the local farmers and are crops with an available market. The necessary tools and implements will also be those commonly employed in the area. Major changes will include the appropriate use of common legumes and the return of all residues to enhance nutrient cycling. The labor involved in these changes is much less than the traditional slash and burn agriculture and thus becomes a more attractive alternative.

Senator Kasten: It is my understanding that the temperature increases will be the greatest in temperate parts of the world. How much temperature variation can we expect to see in tropical zones from this phenomenon?

Dr. Houghton: From my understanding, little or no change in temperature is predicted for the tropical regions. In the tropics, changes in precipitation are more likely to be important, and extremely difficult to predict at this time.

Senator Kasten: Would you comment on the relationship to rainfall of increases in temperature?

Dr. Houghton: In general, a warmer earth will mean greater evaporation and greater rainfall. For a doubling of CO₂ levels, general circulation models (GCM's) predict

an increase in precipitation of 3 to 11% averaged globally. Certain regions may be drier, and the increased precipitation may not occur during agricultural growing seasons. The GCM's generally predict more precipitation north of 30 to 35° N and near the equator, and less precipitation between 5 and 30° N. Records of precipitation over the last 30 to 40 years show trends in this direction.

Senator Kasten: Can we expect to see more erratic rainfall patterns - or possibly less rainfall in critical agricultural areas?

Dr. Houghton: That is my understanding. Several of the GCM's show the agricultural regions of the U.S. midwest to have significantly reduced levels of soil moisture for a doubling of atmospheric CO₂.

Senator Kasten: I was struck by your comment that if tropical deforestation continued at its current rate for another generation, the total carbon release could equal the total fossil fuel carbon release. How reliable is this projection?

Dr. Houghton: Although any projection into the future is speculative, I think the projection cannot be ruled out as a possibility. The projection of tropical deforestation that showed the highest release of carbon (an annual release near the middle of next century equal to the current annual emission from fossil fuels) was a projection based on rates of population growth made by the World Bank and by the U.S. Bureau of Census. The additional assumption of my projection was that future rates of deforestation would be proportional to changes in the rate of population growth. The rationale for this projection was that expanding numbers of people will require an expansion of agricultural resources, at least some fraction of which will be provided by an increased area of crops and pastures available through deforestation. Advances in biotechnology and social mechanisms of food distribution may, of course, alter this projection. But, although advances in technology may increase agricultural yields, these advances are not now available to a large and growing number of people outside economic markets, people who can purchase neither food nor technology but who must use any land available to grow their own subsistence. Furthermore, if rates of deforestation are not to continue to increase, agricultural land will have to be made more sustainable as well as more productive. Some of the deforestation occurring today is to replace worn out or degraded agricultural land. Forests are being converted to agriculture just to keep the area in cultivation constant.

It is noteworthy that the rate of deforestation projected in this projection was 25% lower for all of Latin America in 1987 than the rate observed recently for the Brazilian Amazon alone. For most of the tropics there

are no studies of deforestation after 1980, when the only comprehensive surveys of tropical deforestation were carried out. Current rates of deforestation as well as their associated releases of carbon could be significantly higher than they were in 1980.

SENATOR KASTEN: It is my understanding that the temperature increase will be the greatest in temperate parts of the world. As in temperate zones, can we expect to see agriculture moving into new areas that are not currently cultivated in the tropics?

PROFESSOR TERAMURA: Although temperature increases are generally anticipated to be greater in temperate compared with tropical regions, larger temperature increases may occur in continental (interior) tropical areas such as in southern China and India. The reason for this is that these continental areas do not experience the moderating influences of ocean currents. Additionally, the patterns of precipitation may change, making these interior tropical areas drier than currently experienced. Unlike temperate zones, where agriculture may shift to more northerly latitudes, most tropical countries do not have such large latitudinal boundaries, making it unlikely they can benefit from global warming.

SENATOR KASTEN: Your testimony has focused on the likely impacts of temperature changes on rice production. Would you comment on the likely impacts on other major food materials such as corn and other cereals.

PROFESSOR TERAMURA: Many other cereals may also be adversely influenced. For instance, wheat shows reduced yields at daytime temperatures of 30°C during ripening,

maize experiences reduced pollen germination above 32°C, sorghum shows reduced yields with temperatures in excess of 33°C, and some soybean are of inferior quality when they mature during hot conditions in excess of 32°C.

SENATOR KASTEN: At the same time that we may be turning the "green revolution" into the "brown revolution" in tropical nations, temperate agriculture will also be suffering -- and production will fall. Would you comment on the combined impacts of declines in both temperate and tropical agricultural production.

PROFESSOR TERAMURA: Developed countries have more options available to them since they enjoy a large array of food sources and a significant part of their diet comes from animal protein, where shifts in animal feed could be easily made. In developing countries, such options do not exist or are extremely limited, therefore as agricultural production declines, developing countries face growing problems of food shortages, malnutrition and starvation. Currently, global population growth is increasing faster than agricultural production and this situation will be aggravated by global warming and the resultant decline in global agriculture.

QUESTIONS SUBMITTED BY SENATOR SLADE GORTON

Senator Gorton: What would be the net effect on carbon accumulation or emission if North American forests, managed on a sustained yield basis, were harvested for wood products manufacturing and reforested?

Dr. Houghton: The answer depends on whether the forests to be managed were old-growth forests or secondary forests already harvested in the past. If old-growth

forests were harvested and then managed on a sustained yield basis, there would be a net emission of carbon to the atmosphere. This net emission occurs because the amount of carbon held in an acre of trees and soil in an old-growth forest averages two times the amount of carbon held in an acre of managed forests (see the analysis by Charles F. Cooper, "Carbon storage in managed forests", Canadian Journal of Forest Research 13:155-166, 1983). Old-growth forests hold more carbon because forests managed for sustained yield are harvested before the forests have reached full size, so their maximum carbon stocks are less. In addition, the average carbon content of a managed forest is somewhere between the content of a recently logged forest (low stocks) and the content of an about-to-be-logged forest (intermediate stocks).

There is some accumulation of carbon in the products of the harvest --- accumulation in lumber, in turn, stored in houses, for example. Under normal practices, however, this accumulation is small. Little of the organic matter in a forest is stored in long-lasting products. Most of the tree is left on the forest floor (leaves, branches, stumps, roots) or lost at the saw mill and site of construction (sawdust, waste). Furthermore, houses and wooden furniture do not last forever; there is a constant replacement of wood structures as fire and longer-term decay release the carbon in wood to the atmosphere. The storage in products is small in comparison to the carbon emissions associated with replacing mature or old-growth forests with managed forests.

If the forests to be managed on a sustained yield basis were not old-growth forests, however, but secondary forests previously harvested, the net effect on emissions would theoretically be close to zero. The carbon emitted as a result of the decay of leaves, branches, stumps, roots, sawdust, waste, and the products themselves would be balanced by the accumulation of carbon in regrowing forests.

Senator Gorton: What would be the net effect if the harvesting of mature forests for wood products manufacturing were significantly reduced and reforestation efforts diminished?

Dr. Houghton: If the reforestation efforts to be diminished were those associated with the harvest of mature or old-growth forests, the net effect of reducing both harvest and reforestation on such sites would be a reduction in the amount of carbon emitted to the atmosphere. As answered in the question above, the replacement of old-growth forests with managed forests causes a net release, on average, of two thirds of the carbon originally held in the old-growth forests.

It is true that young, regrowing forests accumulate carbon. But if they are harvested, most of the carbon they have accumulated is emitted to the atmosphere through decay. Little of the accumulated carbon is stored in long-lasting products.

Senator Gorton: In your opinion, which of these options would most significantly contribute to our efforts to combat the "greenhouse" effect and global warming?

Dr. Houghton: A significant reduction in the harvest of old-growth forests, even with the associated reduction in reforestation, will reduce the emissions of carbon to the atmosphere. The continued harvest of old-growth forests with subsequent reforestation for sustained yield will cause a net emission of carbon. Again, although regrowing forests accumulate carbon, the decay of products, of soil organic matter on harvested sites, and of roots, stumps, and slash generated at the time of harvest releases carbon to the atmosphere. The net effect of the two opposing processes, regrowth of young, managed forests and decay of old-growth wood, is a release of carbon from land to the atmosphere. As mentioned above, there is twice as much carbon held in an old-growth forest as in a managed forest. Only if all of the carbon held in an old-growth forest could be sealed from the atmosphere would there be no emission of carbon, but such a strategy seems neither practical nor economically feasible.

Senator Gorton: What additional observation would you make with regard to the temperate and boreal forests of North America and the "greenhouse" effect?

Dr. Houghton: I think the potential of massive reforestation for withdrawing carbon from the atmosphere is great enough to merit a comprehensive study of the area in the U.S. that could be reforested. The study should consider both public and private lands.

I would also add a comment regarding the seriousness of the "greenhouse effect" for North American forests. The warming that has already occurred globally (0.5 degrees centigrade over the last century) and, more importantly, the warming that is predicted to occur over the next 50 to 100 years (1.5 to 4.5 degrees centigrade) may have two effects that amplify the emissions of carbon and, hence, accelerate the rate of further warming. First, a warming will probably increase the rate of decay of organic matter in forest soils and release still more carbon to the atmosphere. And second, if the rate of the warming is as large as predicted for the temperate and boreal zones of the world, the warming may exceed the capacity of tree species to migrate. Widespread mortality of forest trees may then occur, which will cause a large release of carbon to the atmosphere, accelerating the rate of warming. Finally, if the changes in climate include a drying of the forests in these regions, fires, such as those in Canada this year, may become more common and may provide for a further and rapid release of carbon to the atmosphere.

These real possibilities underscore the seriousness of addressing harvest and reforestation policies in the U.S. and elsewhere. Two types of policies are called for. First, there is a clear need to stop further harvest of old-growth stands. Harvesting should be limited to areas already converted to secondary forests. Second, the scale

of reforestation required is much larger than the Conservation Reserve Program (CRP) allows. The CRP is an excellent first step, but the carbon stored per acre in forests established under the CRP is likely to be low. The lands available through the CRP are, for the most part, marginal lands unlikely to support forests with large stocks of carbon. The scale of reforestation required for significant withdrawal of carbon from the atmosphere will require a larger area than available through the CRP and will require land of better quality (i.e., water availability and fertility).

QUESTIONS SUBMITTED BY SENATOR RICHARD LUGAR

ENERGY ACTIVITIES AND GLOBAL WARMING

SENATOR LUGAR: Most analyses indicate that developed countries are the major contributors to factors such as carbon dioxide emissions which are thought to be related to potential increases in average global temperatures. Most of these factors are related to fossil fuel consumption. Although developing countries are not now major contributors to the problem, projections indicate this not to be the case in the future. While we must recognize the rights and needs of developing countries to grow, we must also be aware of the potential long-term environmental costs associated with conventional sources of energy and traditional resource management.

Would you please describe how the current and planned activities of your agency may be able to address the energy needs of developing countries in the context of developing U.S. policies regarding global warming.

MR. BISSELL: A.I.D.'s energy programs reflect the growing concern with global warming through initiatives in energy efficiency improvement (broadly defined), alternatives to fossil fuel consumption, and increased attention to environmental management in the energy sector of developing countries.

According to the best available data, developing countries--including the "newly-industrialized" nations and China--account for about 15 percent of global carbon emissions from fossil fuels. Even including effects on global climate change of deforestation, where developing countries represent more than 90 percent of the total, the overall contribution of developing countries to global warming at this time is only about one-third of the world-wide picture.

China represents about half of the total developing country proportion, and India accounts for about one-third of the remainder. Countries assisted by A.I.D.--which include India, Indonesia, Pakistan, Thailand, and certain other industrializing countries, but not China--contribute about 7 percent of the global total carbon emissions from fossil fuels.

CO₂ emissions from developing countries are increasing rapidly. Rate of growth is the central issue, not the magnitude of current contributions. CO₂ emissions from most developing countries have been growing 6-7 percent since 1973, while emission rates from the U.S., Canada, Western Europe, and Japan have remained just about level. A recent forecast by the Chinese EPA, for instance, showed China's proportional contribution to global warming increasing from a current estimate of 7 percent of the

global total to 28 percent by the year 2100, mainly because of expanded use of domestic coal to provide energy for development.

The mandate of A.I.D. is to assist the economic and social development process in lower-income developing countries, consistent with U.S. policy interests. In line with this charge, A.I.D.'s energy programs have responded to the emerging global warming crisis by supporting technical innovation and commercialization in energy efficiency, alternative energy supply, and fostering sound environmental management in the energy sector of A.I.D.-assisted countries. For example:

1. Energy Efficiency Improvement. In nearly every A.I.D.-assisted country (and China and other developing countries as well), the most promising option is to encourage significant increases in the efficiency of fossil energy conversion and use, especially in the electric power sector. Simply stated, if the systems providing electricity services--from generating plants to transmission and distribution systems, end uses, and load management approaches--can be brought closer to efficiency standards that are both technologically achievable and economically attractive, the same electricity services can be delivered in most countries with one-third less fossil fuel consumption. A.I.D. programs in this respect include:

- o Energy conservation services in over 20 countries, including Egypt and Pakistan;
- o Support for the Central America power sector efficiency improvement project, led by Alvaro Umana, Minister of Natural Resources, Energy and Mines of Costa Rica;
- o Cogeneration initiatives in Thailand, Pakistan, and India;
- o Innovative clear coal technologies that increase conversion efficiency;
- o Energy price reform assistance.

2. Alternative Supply Sources. Even if the most ambitious goals for efficiency improvement can be reached, developing countries will still need more energy supplies to keep their development engines moving forward. This means that economically attractive, realistically implementable alternatives to coal and other relatively high carbon mission fuels are urgently needed. A.I.D. program initiatives include renewable energy sources, emphasizing biomass energy options and small hydropower, and increased attention to natural gas as a relatively low carbon emission, high-efficiency fossil fuel.

3. A.I.D. has actively encouraged progress toward a consistent multiagency policy regarding environmental priorities. Through such mechanisms as the Multiagency Working Group for Power Sector Innovation (MAGPI), created at the impetus of A.I.D., A.I.D. is working to forge a consensus among development assistance agencies, including the major power sector lenders, on policies relative to global warming and other critical environmental issues. This includes coordinating energy and environmental program initiatives, and offering a broad range of technical assistance for investment analyses and institution-building. For example, A.I.D. is collaborating with the World Bank and other agencies to create a microcomputer-based environmental manual for power development for use by both lenders and borrowers to assure that environmental issues are weighted appropriately in making technology choices and investment decisions.

Finally, A.I.D. recently initiated a comprehensive assessment of relationships between all of its programs and the climate change issue (e.g., agriculture, forestry, and health as well as energy).

A report on program connections and possible further initiatives will be available early in Calendar Year 1990.

4. A.I.D. has pioneered a new approach to financing technological innovation and commercialization in environmentally attractive energy technologies in India. PACER (the Program to Accelerate Commercial Energy Research) supports market-driven technology commercialization by Indo-U.S. joint ventures and consortia of Indian firms and R&D institutions. This model is being examined by other advanced developing countries.

GLOBAL WARMING IN RELATION TO ENERGY AND TROPICAL FOREST CONSERVATION

SENATOR LUGAR: Mr. Bissell, with regard to forest management and use, what types of programs do you envision working best in developing countries given the economic attractiveness of using forested lands for agricultural production?

MR. BISSELL: The Agency for International Development (A.I.D.) is pursuing sustainable use, conservation and protection of tropical forests in developing countries through a combination of programs that simultaneously address economic policy reforms and environmental education while striving to meet the needs and the livelihood requirements of local people.

Attention must first be given to changing counterproductive policies. Examination of policies and incentives that promote unsustainable uses of forest lands and ultimately result in economic losses and future productivity declines can form the basis for formulation and acceptance of forward looking policy reforms. Public, popular understanding and support must be increased. Strengthening of indigenous non-governmental conservation organizations and promoting environmental awareness and education programs can simultaneously increase receptivity, interest and support for biological conservation and protection programs for each country's natural heritage.

But while being mindful of both the need for policy reform and public support, A.I.D. remains attentive to the necessity for meeting the needs of local people if real success is to be achieved. Sustainable agricultural crop and livestock production, agroforestry and alternatives to shifting agriculture in buffer zones, land and tree tenure, definition of individual and community roles in natural forest management, forest extraction reserves and a local stake in management of parks and preserves, and in sharing of the economics benefits of nature tourism and local facilities for scientific study of tropical biology all play a role in making local gains toward realizing the final objective of sustaining the tropical forest resources.

CONCLUSION OF HEARING

Senator LEAHY. And I thank all the panelists and all the Senators who came here. We will stand in recess.

[Whereupon, at 12:25 p.m., Wednesday, May 10, the hearing was concluded, and the subcommittee was recessed, to reconvene at the call of the Chair.]